AFOMP Curriculum for Medical Physics Postgraduate Program

Asia-Oceania Federation of Organizations for Medical Physics (AFOMP)

First Edition, 2024

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NB: Those NMOs who will modify the syllabus as per local context please inform AFOMP .

List of Abbreviations

Abbreviation	Definition
AFOMP	Asia-Oceania Federation of Organizations for Medical Physics
AOCMP	Asia-Oceania Congress of Medical Physics
AAPM	American Association of Physicists in Medicine
BED	Biologically Effective Dose
CT	Computed Tomography
CTV	Clinical Target Volume
DVH	Dose-Volume Histogram
EPSM	Engineering and Physical Sciences in Medicine
HDR	High Dose Rate
IAEA	International Atomic Energy Agency
ICRU	International Commission on Radiation Units and Measurements
IMRT	Intensity-Modulated Radiation Therapy
IRR	Induced Repair Response
IVD	In Vivo Dosimetry
LET	Linear Energy Transfer
LDR	Low Dose Rate
LNT	Linear No-Threshold
MRI	Magnetic Resonance Imaging
MU	Monitor Units
MSc	Master of Science
NTCP	Normal Tissue Complication Probability
PDD	Percent Depth Dose
PET	Positron Emission Tomography
PDR	Pulsed Dose Rate
PhD	Doctor of Philosophy
PTV	Planning Target Volume
QA	Quality Assurance
RBE	Relative Biological Effectiveness

SABR	Stereotactic Ablative Radiotherapy
SRS	Stereotactic Radiosurgery
SSD	Source to Skin Distance
TCP	Tumor Control Probability
TG	Task Group
TMR	Tissue Maximum Ratio
TPR	Tissue Phantom Ratio
TPS	Treatment Planning System
3D	Three-Dimensional

Foreword

Dear Colleagues,

The field of medical physics plays a vital role in modern healthcare, providing the scientific and technical foundation for the safe and effective use of radiation and other modalities in medicine. The Asia-Oceania Federation of Organizations for Medical Physics (**AFOMP) Medical Physics Syllabus for Postgraduate program** represents a key effort of our members, led by Professor Dr. Hasin Anupama Azhari, Vice-President AFOMP. This project started under the presidency of Prof. Dr. Arun Chougule to ensure that medical physicists across the Asia-Oceania region are equipped with the knowledge and skills necessary to meet the ever-evolving demands of this dynamic field.

As medical technologies continue to advance at an unprecedented pace, combined with the fast implementation of AI technologies, the need for well-trained medical physicists has never been greater. The increasing complexity of diagnostic imaging, radiation therapy, and nuclear medicine underscores the importance of a standardized, comprehensive training syllabus across our region. This syllabus serves not only as a guide for structured education but also as a tool to harmonize training standards across different countries. This ensures that patients, regardless of where they are treated, benefit from the highest standards of safety and care.

In recognition of the diverse healthcare landscapes in our region, this syllabus is designed with flexibility in mind. While various organizations within AFOMP member countries may have developed their own curricula tailored to local needs, this document aims to complement those efforts by providing a solid, foundational framework. It encourages the adoption of best practices and evidence-based approaches, fostering regional collaboration and knowledge exchange.

I would like to take this opportunity to extend my sincere thanks to the dedicated members of AFOMP, especially the Education and Training Committee under the leadership of Prof Dr. Jin Xiance and the members of the working group (Prof. Dr. Franco Milano, Prof. Dr. Eva Bezak, Prof. Dr. Anchali Krisanachinda, Prof. Dr. Arun Chougule, Dr. Chai Hong Yeong, Prof Dr. Jin Xiance, Prof. Dr. Golam Abu Zakaria, Prof. Dr. Sunil Dutt Sharma, Prof. Dr Hasin Anupama Azhari, Dr. Supriyanto Ardjo Pawiro, Dr. Paul Ravindran) who have contributed their expertise, time, and passion to the creation of this syllabus. Their hard work has resulted in a document that reflects the collective wisdom of professionals who are at the forefront of medical physics in the Asia-Oceania region. This syllabus will undoubtedly contribute to the professional development of medical physicists and, ultimately, to the enhancement of patient care.

Together, we move forward with confidence, knowing that the AFOMP Medical Physics Syllabus for postgraduate program will help shape the future of medical physics education and practice across the region.

Sincerely,
Eva Bezak
President
AFOMP

Preface

Medical Physics is a branch of physics that applies the concepts and principles of physics to the diagnosis and treatment of human disease. The Master's program in Medical Physics is designed for students who wish to pursue a career in Medical Physics, either in a clinical environment or in research. The program provides a strong foundation in diagnostic imaging physics, nuclear medicine physics, radiation oncology physics, radiobiology, and radiation protection, as well as the essential anatomy and physiology knowledge required to understand patients' anatomical structures and physiological processes. The roles and responsibilities of medical physicists have been outlined in the International Organization for Medical Physics (IOMP) Policy Statement 1 (IOMP, 2010).

The International Atomic Energy Agency (IAEA) International Basic Safety Standards (BSS) GSR Part 3 publication clearly states the roles and responsibilities of a medical physicist concerning medical radiation exposure, patient protection, and safety. A medical physicist is defined as a health professional with specialist education and training in the concepts and techniques of applying physics in medicine and is competent to practice independently in one or more of the subfields (specialties) of medical physics, according to the IAEA BSS GSR Part 3 (IAEA, 2014). Furthermore, Medical Physics was classified as a healthcare profession by the International Labor Organization in 2011.

According to the IOMP Statement 2, medical physicists working as healthcare professionals must demonstrate competency in their discipline by obtaining the appropriate educational qualification and clinical competency training in one or more sub-fields of medical physics. Basic knowledge of the other sub-fields is also required. Medical physicists practicing in hospitals or clinical environments must also participate in a continuous professional development program (IOMP, 2010).

The academic education program in medical physics fundamentally prepares a student to enter a formal clinical medical physics residency. It also provides the student with the basic knowledge needed to embark on a career in regulatory, industry, metrology, research and development, or innovation through research sectors. On these broad foundations, students can then build more advanced specialist studies in particular branches of medical physics depending on their aptitude and inclination. Further postgraduate studies would be necessary to pursue a purely academic career in medical physics. An alternative route to enter the medical physics clinical training process for individuals already holding a postgraduate qualification (e.g., Masters or PhD) in physics, engineering, or the equivalent should ensure that the incumbent also takes appropriate academic courses covering all the relevant specialties of medical physics. This could be arranged before or during the period of clinical training. It should also consist of full-time equivalent years, meaning that if the clinical training program includes academic courses, the allocated time for the clinical training should be extended accordingly (IAEA, 2013; IAEA, 2021).

The graduate program aims to produce high-quality medical physics graduates who possess the basic and applied scientific knowledge and the excellent research and communication skills necessary to progress in their careers. Teaching hospitals strongly support the program through curriculum delivery and the provision of research project opportunities. In general, the inter-disciplinary learning environment relies on staff with a deep level of expertise and emphasizes research work through a clinically relevant project that is a large part of the master's program. In addition, the program aims to produce highly motivated, independent thinkers who meet the high standards necessary for progression into medical physics residency and/or further education and research. These graduates are also endowed with professional values, including scientific integrity and ethical behaviour (IAEA, 2013).

The activity of AFOMP aims to promote medical physics and related activities. In most developing countries and lower- and middle-income countries (LMICs) in the AFOMP region, medical physics is not well-recognized in terms of education, profession, and recognition. On the other hand, continuous updates in technology in this profession need to be disseminated in the AFOMP region. Considering this, AFOMP Excom assumes that this can be achieved through the development of a harmonized curriculum for a Master of Medical Physics education program in the AFOMP region.

A Task Group was formed to establish the curriculum for reference by its member countries and beyond. The curriculum is divided into two cores: the first core includes all the mandatory fundamental medical physics courses, and the second core includes the advanced courses of medical physics sub-fields.

This curriculum is constructed based on the recommendations from the IAEA Training Course Series, TCS-56 (IAEA, 2013) and TCS-56 (Rev. 1) (IAEA, 2021), the AAPM, EFOMP, and ESTRO Curriculum for Graduate programs in Medical Physics (AAPM, 2009), and examples of Master of Medical Physics curricula from the AFOMP countries, e.g., Australia, Bangladesh, India, Indonesia, and Malaysia.

This recommended Master of Medical Physics curriculum serves as guidance for the member countries to harmonize the quality of medical physics programs in the region, taking into consideration the various socioeconomic and multicultural factors in the region. This curriculum will also guide AFOMP in minimizing the gaps in medical physics education quality in the region. It is also significant to include any relevant subject, whether core or basic, based on the needs of students in a specific country.

Contributions and Acknowledgements

The AFOMP Education and Training Committee extends its deepest gratitude to the individuals and organizations whose invaluable contributions made the development of this syllabus possible. Their collective expertise, dedication, and tireless efforts have been instrumental in shaping this comprehensive guide for the Master of Medical Physics program.

First Step, 2021: Initial Coordination and Content Finalization

The initial coordination was led by Prof. Dr. Hasin Anupama Azhari, Vice President of AFOMP, whose leadership set the direction for the syllabus. The team was supervised by Prof. Dr. Franco Milano, a distinguished Professor of Medical Physics at the University of Florence, Italy. Under his guidance, the content outline and core elements were meticulously finalized. The invaluable input of the following members was crucial during this phase: Prof. Dr. Franco Milano (Supervisor), Prof. Dr. Eva Bezak, Prof. Dr. Anchali Krisanachinda, Prof. Dr. Arun Chougule, Dr. Chai Hong Yeong, Prof. Dr. Jin Xiance, Prof. Dr. Golam Abu Zakaria, Prof. Dr. Sunil Dutt Sharma, Dr. Supriyanto Ardjo Pawiro, Prof. Dr. Paul Ravindran, and Prof. Dr. Hasin Anupama Azhari (Coordinator). Their combined expertise ensured that the syllabus met the highest standards of academic and professional excellence.

Second Step: Review and Approval by the Education and Training Committee, AFOMP

Following the initial development, the syllabus was thoroughly reviewed by the AFOMP Education and Training Committee (ETC). Led by the ETC chair Prof. Dr. Jin Xiance and his dedicated team, the syllabus was subjected to rigorous scrutiny to ensure it met the needs of the AFOMP region and aligned with international standards. Their approval marked a significant milestone in the syllabus' journey toward completion.

Third Step, 2024: Final Review and Manual Compilation

In the final phase, coordination was done under the leadership of Prof. Dr. Hasin Anupama Azhari, with Prof. Dr. Golam Abu Zakaria, Professor, Anhalt University of Applied Sciences, Germany, supervising the final review and compilation of the manual. This step involved a comprehensive review of the entire syllabus to ensure coherence, accuracy, and practicality.

Special thanks to the dedicated members Mr. Buddhika Srimal Sesath, Medical Physicist, Teaching Hospital, Badulla, Sri Lanka and Mohammad Ullah Shemanto, Junior Medical Physicist, Ahsania Mission Cancer and General Hospital, Dhaka, Bangladesh for assisting the team meticulously. Their commitment to this project ensured that the final product was a robust, well-organized manual that will serve as a valuable resource for medical physics education in the AFOMP region. The final manual was not only comprehensive but also user-friendly, making it an effective tool for educators and students alike. It will be sent to other core members Prof. Dr. Franco Milano, Prof. Dr. Chai Hong, and Prof. Dr. Sunil Datt for their concern.

Lastly After approval of the AFOMP Education and Training Committee followed by AFOMP EXCOM is this syllabus will be present in the AFOMP region. This syllabus is a product of collaboration, dedication, and a shared vision for advancing medical physics education in the region. We extend our heartfelt thanks to all who contributed to this significant achievement.

I. Introduction

A. Background

Medical Physics is one of the specialties of physics that focuses on the use of physical concepts and techniques to support medicine in the diagnosis as well as the treatment of diseases in people. The Master's program in Medical Physics has been designed such that the students can obtain knowledge and skills that prepares them for practice and or research in the medical field. These include diagnostic imaging physics, nuclear medicine physics, radiation oncology physics, and radiobiology, as well as radiation protection and the body of knowledge of anatomy and physiology necessary for professional practice.

Medical physicists' tasks and duties are clearly described on the basis of numerous international documents such as the IOMP Policy Statement 1 and the IAEA International Basic Safety Standards (BSS) GSR Part 3. These documents emphasize that medical physicists play an important role in patients' safety, especially in relation to radiation exposure in the medical field. International Labor Organization accredited medical physicists as members of the healthcare professionals' team and thus, they ought to prove the mastery of their profession through education, training and continued professional development.

The AFOMP (Asia-Oceania Federation of Organizations for Medical Physics) understands that there are diverse levels of development in medical physics about the member countries. In view of an agreed model for educational and training needs, AFOMP has provided a blueprint for a harmonized master's degree program in medical physics. This curriculum is based on AFOMP recommendations and models of other similar programs in countries of this region.

B. Mission

The mission of the AFOMP Curriculum for the Medical Physics Postgraduate Program is to establish a standardized and comprehensive educational framework that ensures the highest level of academic and professional excellence in medical physics across the AFOMP region. The curriculum aims to equip students with the necessary knowledge, skills, and ethical standards to become competent and innovative medical physicists who contribute to the advancement of healthcare, particularly in radiotherapy, diagnostic imaging, and nuclear medicine.

C. Vision

The vision of the AFOMP Curriculum for the Medical Physics Postgraduate Program is to become a globally recognized leader in medical physics education, fostering a generation of medical physicists who are at the forefront of scientific innovation, clinical practice, and research. By harmonizing educational standards across the AFOMP region, the program seeks to enhance the quality of healthcare, improve patient outcomes, and contribute to the global advancement of medical physics.

D. Program Learning Outcome (PLOs)

The Program Learning Outcomes (PLOs) for the Master of Medical Physics program recommended by AFOMP are listed as follows.

On completion of the program, the graduates are expected to:

PLO 1: Apply fundamental laws and physics principles in medical applications.

PLO 2: Formulate strategies to solve complex problems in medical physics using a variety of experimental, analytical, design, statistical, mathematical and/or computational techniques.

PLO 3: Relate the underlying physics principles of specialized medical equipment to its routine operation and its common quality assurance procedures.

PLO 4: Demonstrate an awareness of safety principles, risk management and legislative requirements governing the best practice in the areas of medical physics.

PLO 5: Apply a range of information and communication (ICT) skills to relevant scientific tasks in medical physics, such as the use or design of image processing software, treatment planning systems and medical equipment management systems.

PLO 6: Manage, from initial planning stage to final dissemination of results, an experiment or investigation (requiring a literature review) in a field of medical physics.

PLO 7: Demonstrate a critical awareness of the role of medical physics in medicine considering the technological, social and ethical aspects of the field and its development.

PLO 8: Communicate scientific concepts to an audience of his/her peers in a concise, accurate and informative manner, leading to the presentation of logical conclusions at a level appropriate to the audience.

PLO 9: Manage his/her own learning and make selective use of a variety of resources including appropriate texts, research articles and other primary sources in his/her work.

PLO 10: Critically evaluate experimental findings against previous measurement or the scientific literature, in terms of statistical significance and research methodology.

E. Purpose and Scope of the Syllabus

This syllabus is intended to standardize and structure the curriculum for Master's level education programs in Medical Physics across the AFOMP region. The result should positively influence the standard of medical physics education by ensuring that every student has achieved a sound and consistent disciplinary foundation, covering broad aspects from foundations to frontier areas in the field. This syllabus addresses the needs of the various regions, where differences in levels of development, socioeconomic factors, and cultural contexts can be considerable.

The scope of this document extends to guide academic institutions in the development and upgrading process of their Medical Physics programs and to encourage uniformity in standards of education throughout the region. The syllabus will deal with the main topics of medical physics concerning diagnostic imaging, nuclear medicine, radiation oncology, and radiobiology, while allowing for the possibility of inclusion of other subjects of more specific relevance to the needs of individual countries. The syllabus will include the following major topics essential to the practice of Medical Physics and will present a detailed outline of the knowledge and skills required for competent practice. It will aim at:

1. Medical physics education quality consistency across the different educational systems
2. Facilitate the development and improvement of medical physics programs
3. Regional mobility of medical physics professionals
4. Curriculum development and assessment benchmark

F. Intended Audience

This syllabus is intended for:

1. Educational institutions offering medical physics programs
2. Educators and course coordinators in the field of medical physics
3. Students pursuing careers in medical physics
4. Professional bodies involved in the accreditation of medical physics programs
5. Healthcare organizations employing medical physicists

G. How to Use This Document

The syllabus is structured to provide both an overview and detailed content for each core topic. Users should approach this document as follows:

1. Review the core topics. Overview to understand the breadth of the syllabus.
2. For each core topic, refer to the detailed syllabus section, which includes learning objectives, key concepts, and a content outline.
3. Use the implementation guidelines to adapt the syllabus to specific educational contexts.

This syllabus should be adopted as a template by educators and then adapted to serve local needs, while always containing the underlying competencies The syllabus is not prescriptive in terms of teaching methods or assessment, allowing for innovation and adaptation to diverse learning environments. This document is intended to be a living resource, subject to regular review and updates to reflect advancements in the field of medical physics and educational best practices.

II. Admission Criteria

To become a medical physicist, two main educational and training pathways are recognized.

Pathway 1: This pathway is intended for individuals who have obtained in physics or an equivalent relevant quantitative physical or physics-engineering science core degree. These individuals are eligible to pursue a postgraduate program in Medical Physics, which includes advanced coursework in areas essential to the field. Upon successful completion of the postgraduate program, candidates must engage in 1 to 2 years of supervised clinical training in a healthcare setting. This training provides the practical experience necessary to apply medical physics principles in clinical practice.

Pathway 2: This pathway is designed for those who already hold an MSc or PhD in Physics or an equivalent academic degree. These individuals must first complete additional academic courses in Medical Physics, as recommended by accredited universities. Following the completion of these courses, candidates are required to undertake 1 to 2 years of supervised clinical training, similar to that of Pathway 1.

In both pathways, candidates must obtain certification from the local medical physics association or relevant professional / IMPCB body upon the completion of their academic and clinical training. This certification ensures that the individual has met the standards necessary to practice as a medical physicist, confirming their readiness and competence in the field.

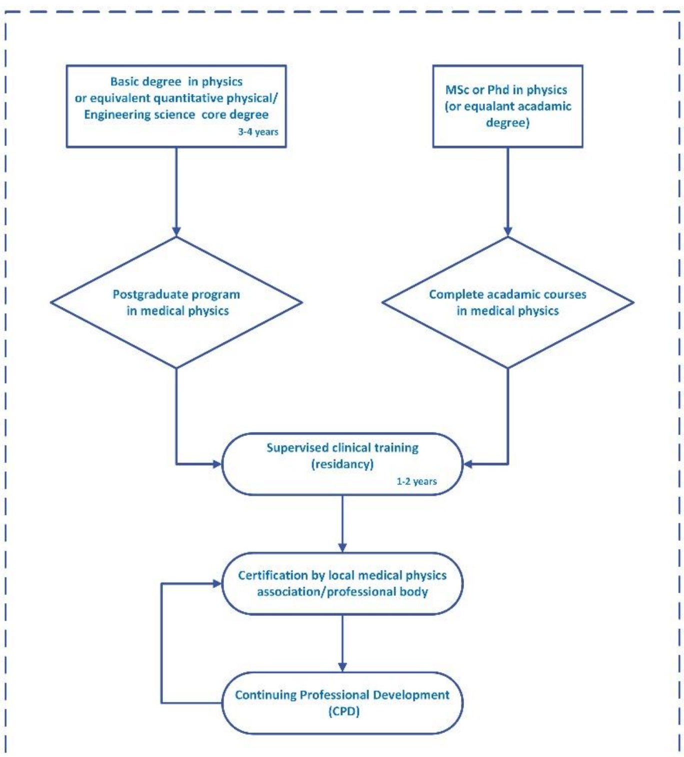

Figure 1:*The recommendations on minimum requirements for the academic education and clinical training of medical physicists*

To entering Medical Physics Postgraduate Program students should have 3 to 4 years undergraduate in Physics or an equivalent quantitative physical or physics - engineering science core degree. However undergraduate degree should be included,

1. At least 2 years of undergraduate level mathematics should be completed with including:
    - Linear Algebra
    - Advanced Calculus
    - Complex variables
    - Differential Equations
    - Numerical Methods`
2. Following Physics topics should be covered during the undergraduate program. If not, they should be completed prior to entry into the medical physics program:
    - Electricity and Magnetism
    - Atomic Physics/Nuclear Physics
    - Quantum Mechanics
    - Classical Mechanics
    - Solid State Physics
    - Modern Physics and Relativity
    - Thermodynamics / Statistical Physics
    - Signal Processing
    - Physics of Fluids and Gases
    - Optics
    - Computational Physics/Computer Programming

The admission requirements for other individuals who have already completed a graduate or post-graduate degree in any other field, should be the same. Generally, universities have well established autonomous criteria to recognize prior learning. A radiation technology diploma or degree is not accepted to enter the Medical Physics postgraduate program. (IAEA 2021)

III. Curriculum Structure

Duration of the program:

Two Years

Number of Semesters:

Four Semesters

Total minimum credit requirement:

60 Credits

Course Distribution

Category Wise Course Distribution

Summary of Course Distribution:

Course Category	Credit
Core Courses (Theory & Practical)	44
Optional/Elective Courses	6
Thesis	10
Total	**60**

Theory courses including Thesis

Theory Core Courses	
Subject	**Credit**
Anatomy and Physiology for Medical Physicists, Fundamental of genetics and Immunology	3
Radiation Physics	3
Essential Mathematics and Physics	3
Computational Skills and Advanced Computational Competences	3
Statistics	3
Radiation Protection for Ionizing Radiations	3
General Image Characteristics	3

Non-Ionizing Radiations in Diagnostic Imaging	3
Ionizing Radiations in Diagnostic Imaging	3
Research Methodology and Professional Development	2
Radiobiology	3
Radiation Dosimetry	3
Radiotherapy Physics, Equipment and Methods	3
Sub Total	**38**
Elective Courses (Any Two)	
Radiation Oncology	6
Accuracy Requirements and Uncertainties in Radiation Medicine	
Artificial Intelligence and Computer-Aided Diagnosis and Therapy	
Micro dosimetry/Advanced Radiation Dosimetry	
Particle Therapy or Special Techniques	
Health Technology Assessment	
Management Principles	
Physics of Human Body	
Diagnostic and Interventional Radiology	
Optical Imaging	
Computational Simulation and Modelling	
Artificial Intelligence and Computer-Aided Diagnosis and Therapy	
Health Technology Assessment	
Management Principles	
Physics of Human Body	
Nuclear Medicine	

Theranostics	
Artificial Intelligence and Computer-Aided Diagnosis and Therapy	
Health Technology Assessment	
Management Principles	
Physics of Human Body	
Sub Total	**6**
Thesis	
Thesis on Radiation Oncology/ Nuclear Medicine/ Diagnostic and Interventional Radiology	10
Total Credits	**54**

Practical Courses:

Practical courses	
Name of the subject	**Credit**
Statistics Lab	1
Radiation Protection for Ionizing Radiations Lab	1
General Image Characteristics Lab	1
Diagnostic Imaging Lab	1
Radiation Dosimetry Lab	1
Radiotherapy Physics, Equipment and Methods Lab	1
Total Credits for Practical Courses	**6**

Year-wise distribution of credits:

Two Years Four Semesters			
Semester	Credit: Theory / Thesis	Credit: Practical	Total
1st Semester	15	1	16
2nd Semester	12	3	15
3rd Semester	11	2	13
4th Semester	16	0	16
Total	54	6	60

Semester wise Courses

First Year First Semester Courses

Course Title		Credit
Anatomy and Physiology for Medical Physicists, Fundamental of genetics and Immunology		3
Radiation Physics		3
Essential Mathematics and Physics		3
Computational Skills and Advanced Computational Competences		3
Statistics		3
Statistics Lab		1
Total	**Theory: 5 Core Subjects 15 credits** **Practical: 1 Core Subjects 1 credits**	**16**

First Year Second Semester Courses

Course Title		Credit
Radiation Protection for Ionizing Radiations		3
Radiation Protection for Ionizing Radiations Lab		1
General Image Characteristics		3
General Image Characteristics Lab		1
Non-Ionizing Radiations in Diagnostic Imaging		3
Ionizing Radiations in Diagnostic Imaging		3
Diagnostic Imaging Lab		1
Total	**Theory: 4 Core Subjects 12 credits** **Practical: 3 Core Subjects 3 credits**	**15**

Second Year First Semester Courses

Course Title		Credit
Research Methodology and Professional Development		2
Radiobiology		3
Radiation Dosimetry		3
Radiation Dosimetry Lab		1
Radiotherapy Physics, Equipment and Methods		3
Radiotherapy Physics, Equipment and Methods Lab		1
Total	**Theory: 4 Core Subjects 11 Credits** **Practical: 2 Core Subjects 2 Credits**	**13**

Second Year Second Semester Courses

Note: 4th Semester (Thesis in any one of the three disciplines along with two Courses as per thesis area is mandatory. Thesis will carry 10 credits, and Each Course will carry 3 credit)

Course Title	**Credit**
Thesis on Radiation Oncology/ Diagnostic and Interventional Radiology/ Nuclear Medicine	10
Elective Courses (Any Two)	
Radiation Oncology	6
Accuracy Requirements and Uncertainties in Radiation Medicine	
Microdosimetry/Advanced Radiation Dosimetry	
Artificial Intelligence and Computer-Aided Diagnosis and Therapy	
Particle Therapy or Special Techniques	
Health Technology Assessment	
Management Principles	
Physics of Human Body	
Diagnostic and Interventional Radiology	
Optical Imaging	
Computational Simulation and Modelling	
Artificial Intelligence and Computer-Aided Diagnosis and Therapy	
Health Technology Assessment	
Management Principles	
Physics of Human Body	
Nuclear Medicine	
Theranostics	

Artificial Intelligence and Computer-Aided Diagnosis and Therapy		
Health Technology Assessment		
Management Principles		
Physics of Human Body		
Total	**Thesis: Thesis in any of the three disciplines is mandatory-10 Credits** **Theory courses: Two elective courses as per thesis area is mandatory – 6 Credits**	**16**

IV. Expanded Syllabus

The AFOMP Curriculum for Medical Physics Graduate Program is a comprehensive and detailed syllabus designed to be a foundation for medical physics education across the Asia-Oceania region. Its purpose is standardization of the training of medical physicists with flexibility to accommodate local needs and resources.

The syllabus embraces all systemically important topics for medical physics practice, starting from the basic sciences through radiation physics and imaging technologies to radiotherapy, radiation protection, and clinical applications. It covers subjects including anatomy and physiology, advanced mathematics and computational skills, statistics, radiobiology, and physics of ionizing and nonionizing radiations

It includes curriculum provision for detailed study of an extremely wide range of medical imaging modalities, including X-ray, CT, nuclear medicine, MRI, ultrasound, radiotherapy physics, equipment, and methods, in addition to ensuring that students come out of the basic knowledge of techniques of treatment planning and delivery.

The syllabus puts general emphasis on safety and quality management by the detail it gives to radiation protection, quality assurance, and regulatory issues. Some of the newer technologies and advanced techniques in both medical imaging and radiation therapy are also reflected in the curriculum

This holistic approach will render the graduate adequately prepared for the multi-faceted role of a Medical Physicist in healthcare. This syllabus shall act as a yardstick for curriculum development, the improvement of already existing programs, and the support mobility of medical physics professionals in the Region.

The AFOMP Core Curriculum is developed with the purpose of enhancing the quality of education in medical physics, by providing a comprehensive and standardized framework of education, in order to finally promote improved care and safety of patients in radiation medicine in the Asia-Oceania region.

1. Anatomy and Physiology for Medical Physicists, Fundamental of genetics and Immunology

Aim:

The aim of this course is to provide medical physics students with a comprehensive understanding of human anatomy and physiology, as well as an introduction to genetics and immunology. This foundation will enable students to accurately apply medical physics principles in the diagnosis and treatment of diseases and enhance their proficiency in interpreting clinical imaging modalities.

Objectives:

1. Anatomical Structures and Functions: Students will learn to identify basic anatomical structures and comprehend the function of the main organ systems.
2. Medical Terminology: Students will become familiar with medical terminology and its application in the clinical setting.
3. Body Organization: Students will understand the general structure and organization of the human body, including the positioning and nomenclature of anatomical structures.
4. Physiology and Systems: Students will grasp the elements of physiology, including the functionality of human organs and systems.
5. Clinical Imaging: Students will be able to identify anatomical structures using various clinical imaging modalities.

Course Contents

- **Basic Anatomical Structures**: General structure and organization of the body, Medical terminology, Basic anatomy: structure, position, and nomenclature.
- **Function of Main Organ Systems**: Elements of physiology, Human organs and systems.
- **Clinical Imaging and Anatomical Identification**: Identification of anatomical structures in clinical imaging modalities (CT,MRI and nuclear medicine imaging) of Skeleton and bone marrow, Brain, Centran nervous system, Thorax, Abdoman, Pelvis.
- **Disease, Trauma, and Function Examination:** Introduction to the nature and effects of disease and trauma, Principles of function examination for at least one organ system.
- **Visual Perception and Fundamentals of Genetics and Immunology**: Elements of visual perception, Fundamentals of Genetics and Immunology.

Learning Resources

Textbooks

- TORTORA, G.J., DERRICKSON, B.H., Principles of Anatomy and Physiology, 13th Edition, John Wiley & Sons, Inc., New Jersey, USA (2012).
- EIR, J., ABRAHAMS, P.H., SPRATT J.D., SALKOWSKIET L.R., Imaging Atlas of Human Anatomy, 4th Edition. Mosby, Maryland, USA (2010).

Reference Books

- Ganong's Review of Medical Physiology A Lange Medical Book, Twenty-Fifth Edition, Barrett, Barman, Boitano, Brooks, New York Chicago San Francisco Lisbon London Madrid Mexico City (2016)

Other Resources (Online Resources or others)

- Anatomy Expert (http://www.anatomyexpert.com/): Free resources to help study anatomy including artwork, models, cross-sections, and photographs.
- Anatomy Zone (https://anatomyzone.com/): Free anatomy videos, questions, flashcards, tutorials, and a 3D atlas.
- Videos for human anatomy & physiology
- (https://www.youtube.com/channel/UCJzco_RimSMKvH7sg7TWoGw/videos):
- Georgia Highlands College videos for Human Anatomy and Physiology. Videos range from 1-3 minutes and are very in-depth/descriptive.

2. Radiation Physics

Aim:

The aim of the Radiation Physics course is to provide students with a comprehensive understanding of the fundamental principles and interactions of ionizing radiation with matter. This course is designed to equip students with the theoretical and practical knowledge required to analyze and apply radiation physics concepts in various medical and scientific contexts.

Objectives:

1. Understanding Interactions with Matter: Students will gain a thorough understanding of how ionizing radiation interacts with matter, including the different types of interactions and their implications.
2. Radiation Fields and Statistics: Students will learn about the properties of radiation fields and their statistical behavior, including fluence, fluence rate, energy fluence, and angular and energy distributions.
3. Charged Particle Interactions: Students will explore the different types of charged particle interactions, including ionization, secondary ionization, specific ionization, and the effects of elastic and inelastic interactions.
4. Photon Interactions: Students will study the various ways photons interact with matter, such as coherent scattering, the photoelectric effect, Compton scattering, and pair and triplet production, as well as the factors affecting these interactions.
5. Neutron Interactions: Students will investigate neutron interactions, including elastic and inelastic scattering, neutron capture, nuclear spallation, and neutron-induced fission, with a particular focus on interactions within biological tissues.

Course Contents

- **Overview of Modern Physics:** Historical overview, Atomic and nuclear structure , Radioactive decay, Elementary quantum mechanics.
- **Interactions of Ionizing Radiation with Matter:** Stochastic and Non-stochastic quantities, Fluence and fluence rate, Energy Fluence and Energy Fluence Rate, Angular distributions, Energy Distributions
- **Charged Particle Interactions:** Types of charged particles, Ionization and Secondary Ionization, Specific Ionization, Excitation, Elastic and inelastic interactions, Electronic stopping power for electron and positron, Radiative energy loss: bremsstrahlung, Restricted electronic stopping power, Linear Energy Transfer (LET), Range
- **Photon Interactions:** Coherent Scattering, Photoelectric Effect, Fluorescence photons and auger electrons, Compton Scattering, Pair and triplet production, Positron Annihilation, Photonuclear interactions, Photon interaction coefficients
- **Photon Attenuation:** Narrow and broad beam attenuation, Photon attenuation coefficient, Broad beam attenuation, Build-up factors

- **Neutron Interactions:** Elastic and inelastic scattering, Neutron capture, Nuclear spallation, Neutron-induced fission, Neutron interaction in tissues
- **Radiation Equilibrium:** Fano's theorem, Charged particle equilibrium, Exposure, Transient charged particle equilibrium
- **Radioactive Decay:** Modes of radioactive decay, Alpha decay, Beta decay, Electron capture, Gamma decay, Internal conversion, Proton and neutron emission decays, Radioactive series decay, Equilibria in parent-daughter activities
- **Production of Radionuclides:** Naturally occurring radionuclides, Artificial radionuclides, Nuclear activation, Nuclear fission, Radionuclide generators

Learning Resources

Textbooks

- PODGORSAK, E. B., Radiation Physics for Medical Physicists (Biological and Medical Physics, Biomedical Engineering), 2nd Edition, Springer, New York, USA (2010).
- ANDREO, P., BURNS, D.T., NAHUM, A.E., SEUNTJENS, J., ATTIX, F.H., Fundamentals of Ionizing Radiation Dosimetry, Second Edition, Wiley-VCH, Weinheim, GERMANY (2017).
- Khan's The Physics of Radiation Therapy, Sixth Edition by Faiz M. Khan Ph.D. (Author), John P. Gibbons Ph.D. (Author), (2019)
- Johns and Cunningham's The Physics of Radiology 4th Edition by Eva Bezak (Author), Alun H Beddoe (Author), Loredana G Marcu (Author), Martin Ebert (Author), Roger Price (Author) (1983).
- Radiation Oncology Physics: A Handbook for Teachers and Students, International Atomic Energy Agency, Vienna, 2005

Reference Books

- Hand book of Radiotherapy Physics, 1st Edition, P.Mayles, A. Nahum, J-C Rosenwald, Institute of Physics Publishing, 2007
- The Modern Technology of Radiation Oncology, 2nd Edition, Van Dyke J (Ed.). Medical Physics. Medical Physics Publishing Corporation, 2005, Madison, WI, United States

Other Resources (Online Resources or others)

- Radiation Oncology Physics Slides by IAEA
- EMERALD, EMIT, EMITEL
- http://www.sprawls.org/resources/

3. Essential Mathematics and Physics

Aim:

The aim of the Essential Mathematics and Physics course is to provide students with a solid foundation in the fundamental principles of mathematics and physics. This course is designed to enhance students' analytical and problem-solving skills, enabling them to apply mathematical and physical concepts in various scientific and medical contexts.

Objectives:

1. Mastering Mathematical Techniques: Students will develop proficiency in linear algebra, matrix analysis, trigonometry, and analytical geometry, laying the foundation for advanced mathematical applications.
2. Functions and Calculus: Students will understand limits and functions, differentiation, and integration, and how to apply these concepts to solve real-world problems.
3. Advanced Mathematical Concepts: Students will explore advanced mathematical concepts such as exponential and logarithmic functions, trigonometric and hyperbolic functions, infinite series, matrices, ordinary differential equations, Laplace transforms, and vector analysis.
4. Differential Equations and Vector Calculus: Students will gain a deep understanding of partial derivatives, multiple integrals, Fourier series, partial differential equations, and complex functions, equipping them with the tools needed for sophisticated mathematical modeling.
5. Essential Physics Knowledge: Students will be introduced to the principles of thermal physics, including the concepts of temperature, heat transfer, and the laws of thermodynamics, as well as waves, optics, electricity, magnetism, mechanics, and the properties of matter.

Course Contents

- **Linear Algebra and Matrix Analysis:** Numbers, Trigonometry, Analytical Geometry, Limits and Functions, Differentiation, Integration, Exponential and Logarithmic Functions, Trigonometric and Hyperbolic Functions, Infinite Series, Matrices, Ordinary Differential Equations, Laplace Transforms, Vector Analysis, Partial Derivatives, Multiple Integrals, Fourier Series, Partial Differential Equations, Complex Functions, Numerical Methods.
- **Essential Physics:** Thermal Physics, Temperature, Heat and Solids, Heat Transfer, Gases, Work and Thermodynamics, Gas Processes, Kinetic Theory of Gases, Entropy.
- **Wave and Optics:** Periodic Motion, Waves, Light, Mirrors, Lenses, Optical Instruments, Interference, Diffraction, Polarization.
- **Electricity and Magnetism:** Electricity, Magnetism, Induction, Magnetic Circuits, R-C and R-L Circuits, Electromagnetic Waves.
- **Mechanics and Properties of Matter:** Scalars and Vectors, Statics, Moment of Inertia, Linear Motion, Forces, Rotational Motion, Rotation, Work and Energy, Impulse and Momentum, Properties of Matter, Fluids, Solids, Matter.

Learning Resources

Textbooks

- Contemporary Linear Algebra, Howard Anton, Robert C. Busby (HR), John Wiley & Sons; 1st edition (September 2, 2002)
- Elementary Differential Equations, Boyce & Diprima (BD), Wiley; 9th edition (October 3, 2008)
- Calculus Early Transcendentals, Howard Anton, Irl Bivens, Stephen Davis, [10th Edition], 2012
- Fundamentals of Physics - D. Halliday, R. Resnick & J. Walker (10th Ed.), 2015

Reference Books

- Fundamentals of Complex Analysis- Saff and Snider, Pearson; 3rd edition, (January 10, 2003)
- Fourier and Laplace transforms- R. J. Beerends, H. G. ter MorscheJ. C. van den Berg and E. M. van de Vrie, Cambridge University Press; 1st edition (August 25, 2003)
- University PhysicsSears, Zemansky, Young & Freedman (12th Ed.), Pearson Education, Limited, 2009
- Fundamental of Electrical Circuits- Alexander & Sadiku (5th Edition), 2012
- A Textbook of Optics- N. Subramanyam & Brij Lal (23rd Ed.), 2006
- Fundamentals of Optics - F. A. Jenkins & H. E. White, (4th Ed.), 1976.
- Vibrations and Waves - A. P. French, CBS Publishers & Distributors Pvt Ltd, India (April 30, 2003)
- Waves and Oscillations, N. Subramanyam & Brij Lal, (2nd Ed.), 2018
- Physics Vol. I - Halliday, Resnick & Krane, 5th Edition, 2001

4. Computational Skills and Advanced Computational Competences

Aim:

The aim of the Computational Skills and Advanced Computational Competences course is to equip students with a broad range of computational skills and advanced techniques necessary for the effective application and innovation within the field of medical physics.

Objectives:

1. Develop Foundational Computational Skills: Students will acquire basic computer skills, including proficiency in spreadsheet software, word processing, and presentation software, as well as image viewing and processing tools. They will also learn to effectively utilize search engines and access scientific journals for research purposes.
2. Master Programming and Data Analysis: Students will learn the fundamentals of computer science, data structures, memory management, and programming in high-level languages like Python, MATLAB. This includes understanding syntax, data types, logic, and iterative programming.
3. Understand Signal and Image Processing: Students will explore signal processing and image processing techniques, including analog-to-digital conversion, Fourier transforms, common filters, image analysis, and compression methods. They will gain practical skills in processing digital images and signals for medical applications.
4. Explore Machine Learning and Particle Transport: Students will be introduced to machine learning techniques, including supervised and unsupervised learning, and reinforcement learning. They will also study the application of Monte Carlo techniques and dose calculation algorithms relevant to particle transport and medical imaging.
5. Grasp Medical Informatics and Networking: Students will learn about medical informatics, including networking types, communication protocols, and cloud storage. They will delve into standards like DICOM and PACS, understanding their importance in healthcare integration and data management.

Course Contents

- **Programming Skills:** Syntax, Data types (floating point variables, integers, strings, arrays), Declaration of variables, Logic, Boolean operators, switches, and conditional statements, Iterative programming, Methods, functions, programs, executables, compilation, and input/output.
- **Signal Processing:** Introduction to signal processing, what it's for, where it's used, Brief revision of statistics, probability, and noise, Analog/digital conversion, Continuous and discrete signals, quantization and sampling, Linear systems, Convolution, Fourier Transform (FT) and Discrete Fourier Transform (DFT), introduction to frequency analysis, Common filters and their uses, High/low/band pass, average, Butterworth, etc.

- **Image Processing:** Digital image structure and representation, Color spaces and bit depth, Image analysis techniques, Image processing techniques by slices, volumes, time, Image and data compression, Lossless, lossy psychovisual techniques.
- **Machine Learning:** Supervised learning (Classification, Regression), Unsupervised learning (Principal Component Analysis, Clustering), Reinforcement learning.
- **Particle Transport:** Linear Boltzman equation, Applications of Monte Carlo technique, Dose calculation algorithms: convolution, superposition.
- **Medical Informatics:** Networking, Types of networks, data rate, bandwidth, Network infrastructure, Wide Area Network (WAN), Local Area Network (LAN), Communication Protocols: TCP/IP and OSI Models, Cloud storage, Communication Standards, DICOM, Health Level Seven, Integrating the Healthcare Enterprise, DICOM and DICOM-RT, Service object pairs, association negotiation, Information model elements (Image, Series, Study, Patient, Instances, Unique Identifiers), DICOM tags & modules, DICOM anonymization, Databases, Tables and fields, Database schema, Data dictionary, Queries and SEQUEL language, Client server database model, Backup, Picture Archive and Communication System (PACS).
- **Advanced Topics in Radiotherapy:** Radiomics, Theranostics; connection to genetics and other omics, Immunotherapy + RT, RT for non-cancer treatments (e.g., Cardiac ablation), FLASH, Cerenkov imaging (applications for RT, proton and heavy ion therapy), Chemotherapy + RT, Photodynamic Therapy (PDT) + RT, High-Intensity Focused Ultrasound (HIFU) + RT, Tumor Treating Fields (TTF).
- **Advanced Topics in Diagnostic Imaging:** Alternative x-ray sources (synchrotron; inverse-Compton scatter/laser-particle accelerators), Radiomics, Theranostics; connection to genetics and other omics, CAD and AI/machine learning (beyond the basics), X-ray interferometry, Nanomedicine (contrast agents), Photon counting x-ray detectors.
- **Advanced Topics in Nuclear Medicine:** Theranostics, Nanomedicine (radiotracers for imaging and/or therapy), Radiotracer development/radiochemistry, Personalized dosimetry, Image-guided surgery, surgical planning based on imaging, augmented reality, virtual tools, CAD and AI/machine learning (beyond the basics).
- **Other Advanced Topics:** Automated analysis, pathology image display and archiving, etc., Laser surgery, optical modeling, corrective optics, Mechanical modeling, 3D planning, 3D optical reconstruction in Dentistry, Mechanical modeling, motion analysis, hardware design in Orthopedics, Electrophysiology, mechanical modeling, flow modeling in Cardiology, Neuroscience, psychology, psychiatry (e.g., incorporation of imaging in diagnosis and monitoring).

Learning Resources

Textbooks

- Introduction to the Theory of Computation, Michael Sipser, 3rd edition, 2012.
- Computer Systems: A Programmer's Perspective, Randal E. Bryant and David R. O'Hallaron, 3rd edition, 2015.
- Digital Image Processing, Rafael C. Gonzalez and Richard E. Woods, 4th edition, 2018.
- Signals and Systems, Alan V. Oppenheim and Alan S. Willsky, 2nd edition, 1996.
- Biomedical Informatics: Computer Applications in Health Care and Biomedicine, Edward H. Shortliffe and James J. Cimino, 4th edition, 2013.

5. Statistics

Aim:

The aim of this course is to provide students with a comprehensive understanding of statistical concepts, techniques, and applications relevant to medical physics and healthcare research.

Objectives:

1. Descriptive Statistics Mastery: Students will learn to describe and summarize data using measures of central tendency, dispersion, moments, skewness, and kurtosis, and will become proficient in presenting data in tabular and graphical forms.
2. Probability Fundamentals: Students will gain a solid understanding of probability, including the concepts of events, sample spaces, independent events, conditional probability, and Bayes' theorem.
3. Random Variables and Distributions: Students will explore the properties and applications of random variables, including discrete and continuous types, and will study various probability distributions and their expectations.
4. Statistical Inference: Students will be introduced to parametric and non-parametric models, point estimation, hypothesis testing, and Bayesian inference, equipping them to draw meaningful conclusions from data.
5. Regression and Multivariate Analysis: Students will develop skills in linear and logistic regression, as well as multivariate modeling, enabling them to analyze complex datasets and make informed decisions in healthcare settings.

Course Contents

- **Descriptive Statistics:** Definition and scope, Concepts of statistical population and sample, Data: quantitative and qualitative, cross-sectional and time-series, discrete and continuous, Scales of measurement: nominal, ordinal, interval, and ratio, Presentation of data: tabular and graphical, Frequency distributions, cumulative frequency distributions and their graphical representations.
- **Measures of Central Tendency:** Mean, Median, Mode.
- **Measures of Dispersion:** Range, mean deviation, Standard deviation, Coefficient of variation, Gini's Coefficient, Lorenz Curve, Moments, skewness, and kurtosis, Quantiles and measures based on them.
- **Probability:** Sample, spaces, events, Probability, Probability of finite sample spaces, Independent events, Conditional probability, Bayes' Theorem.
- **Random Variables:** Distribution functions and probability functions, Discrete random variables, Continuous random variables, Bivariate distributions, Marginal distributions, Independent random variables, Multivariate distributions.
- **Expectation:** Expectation of a random variable, Variance and covariance.
- **Statistical Inference:** Parametric and non-parametric models, point estimation, Confidence set, Hypothesis testing, The Wald test, p-values, The chi-squared (χ^2) distribution, Bayesian inference, Linear and logistic regression, Multivariate models.

Learning Resources

Textbooks

- Statistical Methods (Volume 1 and 2); N G Das; Mcgraw Hill Education; 1st Edition, 2008.

Reference Books

- Fundamentals of Mathematical Statistics,10th Edition, S.C.Gupta and V.K.Kapoor, S.Chan and Co; (2000)

6. Statistics Lab

Aim: To equip students with practical skills in statistical analysis and interpretation of data through hands-on experience with various statistical techniques and tools.

Objectives:

1. Develop Proficiency in Data Presentation: Students will be able to effectively present data using graphical and diagrammatical methods, including drawing accurate graphs and diagrams to illustrate data trends.
2. Apply Measures of Central Tendency and Dispersion: Students will calculate and interpret measures of central tendency (mean, median, mode) and dispersion (range, variance, standard deviation) and analyze comparisons between different data sets.
3. Conduct Correlation and Regression Analysis: Students will perform correlation and regression analyses to determine relationships between variables, calculate regression and correlation coefficients, and understand their significance.
4. Execute Tests of Significance: Students will apply various significance tests (including t-tests, χ2-tests, and F-tests) to assess hypotheses and determine statistical significance of their results.
5. Interpret Statistical Results: Students will gain skills in interpreting and evaluating statistical results, including understanding the practical implications of their analyses and tests within a given context.

Course Contents

- **Graphical and Diagrammatical Presentation of Data:** Drawing of Graphs and Diagrams
- **Measures of Central Tendency and Dispersion:** Calculation of Arithmetic Mean, Geometric Mean, Harmonic Mean, Median, Mode, Range, Mean Deviation, Standard Deviation, Coefficient of Variation and Comparison between two or more sets of observations.
- **Correlation and Regression Analysis:** Calculation of Regression and Correlation Coefficients, Standard error and their significance test.
- **Test of Significance:** Simple significance test based on the Normal Distribution, Comparison of means of two large samples, Students t-test, χ2-test, F-test.

Learning Resources

Textbooks

- Statistical Methods (Volume 1 and 2); N G Das; Mcgraw Hill Education; 1st Edition, 2008.

Reference Books

- Fundamentals of Mathematical Statistics,10^{th} Edition, S.C.Gupta and V.K.Kapoor, S.Chan and Co; (2000)

7. Radiation Protection for Ionizing Radiations

Aim:

The Radiation Protection for Ionizing Radiations course aims to equip students with the knowledge and skills necessary to assess radiation risks and implement effective radiation protection measures to safeguard individuals, populations, and the environment.

Objectives:

1. **Radiation Risk Assessment:** Students will learn to evaluate radiation risks, understanding both deterministic and stochastic effects of ionizing radiation on the human body, including genetic and somatic hazards.
2. **Radiation Protection Principles:** Students will study the fundamental principles of radioprotection, including the concepts of justification, optimization, limitation, and the ALARA principle. They will also learn about dose limits and dose constraints for workers and the general population.
3. **Radiation Monitoring and Patient Protection:** Students will explore radiation monitoring techniques, including the classification of areas, personal monitoring, and patient protection measures, particularly concerning the embryo, fetus, and the risks of leukaemogenesis and carcinogenesis.
4. **Scientific and Regulatory Foundations:** Students will understand the scientific basis of radiation protection, including national and international rules, organizations, and legislation that govern radiation safety. They will also learn about the administration and organization of radiation protection programs.
5. **Radiation Safety Management:** Students will be introduced to the design and management of facilities using ionizing radiation, including treatment and imaging rooms, and the safe storage of radioactive materials. They will also learn about hazard assessments, contingency plans for accidents, and the management of radioactive material transport and waste disposal.

Course Contents

- **Radiation Risk Assessment:** Deterministic and stochastic effects, Quantities and units in radiation protection.
- **Basic Principles of Radioprotection:** Justification, Optimization, Limitation, ALARA principle, Dose limits, Dose constraints (workers, population).
- **Radiation Monitoring:** Classification of areas, Personal monitoring.
- **Patient Protection:** Effects of radiation on the embryo and fetus, Leukemogenesis and carcinogenesis, Genetic and somatic hazards for exposed individuals and populations, Approaches for optimizing and minimizing radiation doses to patients.
- **Scientific Basis of Radiation Protection:** Administration and organization of radiation protection, National and international rules and organizations, National and international legislation.

- **Design and Facilities:** Treatment rooms, Imaging rooms, Sealed and non-sealed source storage, Layout planning and shielding calculations.
- **Management of Radiation Safety:** Hazard assessment, Contingency plans, Accidents in radiotherapy, Radioactive material management, Transport and waste disposal.

Learning Resources

Textbooks

- International Commission on Radiation Units and Measurements, Operational Quantities for External Radiation Exposure, ICRU Report No. 95, Bethesda, MD (2021).
- European Commission, Food and Agriculture Organization of the United Nations, International Atomic Energy Agency, International Labour Organization, OECD Nuclear Energy Agency, Pan American Health Organization, United Nations Environment Programme, World Health Organization, Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards, IAEA Safety Standards Series No. GSR Part 3, IAEA, Vienna (2014).
- International Commission on Radiological Protection, The 2007 Recommendations of the International Commission on Radiological Protection, ICRP Publication 103, ICRP, Ottawa (2007).
- International Atomic Energy Agency, IAEA, Safety Assessment for Facilities and Activities: General Safety Requirements, Part 4 (Rev. 1), IAEA, Vienna (2016)
- Khan's The Physics of Radiation Therapy, Sixth Edition by Faiz M. Khan Ph.D. (Author), John P. Gibbons Ph.D. (Author), (2019)
- Johns and Cunningham's The Physics of Radiology 4th Edition by Eva Bezak (Author), Alun H Beddoe (Author), Loredana G Marcu (Author), Martin Ebert (Author), Roger Price (Author) (1983).
- Radiation Oncology Physics: A Handbook for Teachers and Students, International Atomic Energy Agency, Vienna, 2005

Reference Books

- Hand book of Radiotherapy Physics, 1st Edition, P.Mayles, A. Nahum, J-C Rosenwald, Institute of Physics Publishing, 2007.
- PODGORSAK, E. B., Radiation Physics for Medical Physicists (Biological and Medical Physics, Biomedical Engineering), 2nd Edition, Springer, New York, USA (2010).
- The Modern Technology of Radiation Oncology, 2nd Edition, Van Dyke J (Ed.). Medical Physics. Medical Physics Publishing Corporation, 2005, Madison, WI, United States

Other Resources (Online Resources or others)

- European Medical Radiation Learning Development (EMERALD): http://www.emerald2.eu/emerald_index.html

- Medical physics encyclopedia and multilingual dictionary: http://www.emitel2.eu/emitwwwsql/index-login.aspx
- Sprawls, P.: http://www.sprawls.org/resources/

8. Radiation Protection for Ionizing Radiations Lab

Aim:

The Radiation Protection for Ionizing Radiations Lab aims to provide students with practical experience in implementing radiation safety measures and protocols, reinforcing their understanding of theoretical concepts through hands-on experimentation and observation.

Objectives:

1. **Application of Radiation Protection Principles:** Students will apply the principles of radiation protection, including the concepts of justification, optimization, and limitation, in a controlled laboratory environment.
2. **Radiation Monitoring Techniques:** Students will gain hands-on experience in using various radiation monitoring equipment, learning to classify areas, perform personal monitoring, and ensure patient protection.
3. **Safety Management:** Students will learn to design and implement effective radiation safety management plans, including hazard assessment, contingency planning, and the management of radioactive material transport and waste disposal.
4. **Emergency Response Training:** Students will participate in simulated radiological emergency scenarios to practice and refine their skills in responding to accidents and unexpected radiation exposures.
5. **Data Analysis and Reporting:** Students will develop the skills necessary to analyze radiation monitoring data and prepare comprehensive reports that communicate their findings and recommendations.

Course Content:

- **Introduction to Laboratory Safety and Protocols:** Overview of radiation protection principles, Laboratory safety procedures, Introduction to radiation detection and monitoring equipment.
- **Radiation Monitoring and Measurement:** Use of dosimeters, survey meters, and other detection equipment, Techniques for area classification and personal monitoring, Data collection and analysis.
- **Radiation Safety Management:** Design and setup of treatment and imaging rooms, Procedures for the safe storage and transport of radioactive materials, Waste management and disposal practices.
- **Emergency Preparedness and Response:** Development of contingency plans for radiological emergencies, Simulation of accident scenarios and emergency response drills, Post-incident analysis and reporting.

- **Regulatory Compliance and Reporting:** Understanding of national and international radiation safety regulations, Preparation of reports for regulatory compliance, Communication of safety measures and incident findings.

Learning Resources

Textbooks

- International Commission on Radiation Units and Measurements, Operational Quantities for External Radiation Exposure, ICRU Report No. 95, Bethesda, MD (2021).
- European Commission, Food and Agriculture Organization of the United Nations, International Atomic Energy Agency, International Labour Organization, OECD Nuclear Energy Agency, Pan American Health Organization, United Nations Environment Programme, World Health Organization, Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards, IAEA Safety Standards Series No. GSR Part 3, IAEA, Vienna (2014).
- International Commission on Radiological Protection, The 2007 Recommendations of the International Commission on Radiological Protection, ICRP Publication 103, ICRP, Ottawa (2007).
- International Atomic Energy Agency, IAEA, Safety Assessment for Facilities and Activities: General Safety Requirements, Part 4 (Rev. 1), IAEA, Vienna (2016)
- Khan's The Physics of Radiation Therapy, Sixth Edition by Faiz M. Khan Ph.D. (Author), John P. Gibbons Ph.D. (Author), (2019)
- Johns and Cunningham's The Physics of Radiology 4th Edition by Eva Bezak (Author), Alun H Beddoe (Author), Loredana G Marcu (Author), Martin Ebert (Author), Roger Price (Author) (1983).
- Radiation Oncology Physics: A Handbook for Teachers and Students, International Atomic Energy Agency, Vienna, 2005

Reference Books

- Hand book of Radiotherapy Physics, 1st Edition, P.Mayles, A. Nahum, J-C Rosenwald, Institute of Physics Publishing, 2007.
- PODGORSAK, E. B., Radiation Physics for Medical Physicists (Biological and Medical Physics, Biomedical Engineering), 2nd Edition, Springer, New York, USA (2010).
- The Modern Technology of Radiation Oncology, 2nd Edition, Van Dyke J (Ed.). Medical Physics. Medical Physics Publishing Corporation, 2005, Madison, WI, United States

Other Resources (Online Resources or others)

- European Medical Radiation Learning Development (EMERALD): http://www.emerald2.eu/emerald_index.html
- Medical physics encyclopedia and multilingual dictionary : http://www.emitel2.eu/emitwwwsql/index-login.aspx
- Sprawls, P.: http://www.sprawls.org/resources/

9. General Image Characteristics

Aim:

The aim of the course is to equip students with a comprehensive understanding of the principles and techniques involved in generating, processing, and analyzing medical images. Students will learn to enhance image quality and extract quantitative information, crucial for accurate diagnosis and effective treatment planning.

Objectives:

1. **Understanding Image Representation:** Students will gain a deep understanding of image representations, including pixels, bytes, field-of-view, image matrix, and how these elements influence the quality and interpretation of medical images.
2. **Mastering Image Processing Techniques:** Students will become proficient in image processing techniques, such as edge enhancement, smoothing, segmentation, and noise reduction, enabling them to improve the clarity and diagnostic value of medical images.
3. **Exploring Advanced Reconstruction Methods:** Students will explore various image reconstruction methods, including back-projection, filtered back-projection, and iterative reconstruction methods, learning how these approaches affect image resolution and accuracy.
4. **Application of Quantitative Analysis:** Students will apply quantitative analysis techniques to measure object size, shape, texture, motion, and flow in medical images, enhancing their ability to make precise clinical assessments.
5. **Integration of Artificial Intelligence:** Students will explore the application of artificial intelligence, machine learning, and deep learning in medical imaging, understanding how these technologies can aid in detection, diagnosis, and image enhancement.

Course Contents

- **Image Representations:** Pixels, Bytes, Field-of-View, and the Image Matrix, Grayscale and Color Images, Spatial Frequency and Frequency Space, Aliasing: Temporal, Spatial, and Bit-Depth, Nyquist Limit, Axial, Multi-planar, and Curvilinear Reconstructions, Maximum and Minimum Intensity Projections, Surface and Volume Rendering, Multi-Modal Imaging, Time-Resolved Imaging, Quantitative Imaging and Representation of Physical Data, Overlays, Color Maps, and Vectors.
- **Data Acquisition:** Analog to digital converters, Dynamic range and resolution, Sampling frequency and bandwidth, Digital oversampling.
- **Image Reconstruction:** Back projections, Sinograms, Filtered back projections, Simple Back-Projection, Iterative Reconstruction Methods.

- **Image Processing:** Non-Uniformity and Defect Correction, Image Subtraction and Noise, Segmentation and the Region-of-Interest, automated vs. Semi-automated vs. Manual, Look-up Tables (LUT), Window and Level, Nonlinear Tables and Characteristic Curves, Histogram and Equalization, Value of Interest, Anatomical Frequency Processing, Edge Enhancement, Un-sharp Masking, Smoothing, Digital Magnification (Zoom).
- **Quantitative Analysis:** Object Size Measurement, Shape and Texture, Motion and Flow.
- **Computer-Aided Detection and Diagnosis, Machine Learning, and Deep Learning:** Artificial Intelligence, Enhancement, Image fusion, Spatial resolution, Signal to noise ratio, Contrast to noise ratio.

Learning Resources
Textbooks

- The Essential Physics of Medical Imaging, Jerrold T. Bushberg, J. Anthony Seibert, Edwin M. Leidholdt Jr., and John M. Boone, 4th edition, 2020.
- Machine Learning for Medical Image Analysis, S. Kevin Zhou, Hayit Greenspan, and Dinggang Shen, 1st edition, 2017.
- Digital Image Processing, Rafael C. Gonzalez and Richard E. Woods, 4th edition, 2018.
- Introduction to Medical Imaging: Physics, Engineering and Clinical Applications, Nadine Barrie Smith and Andrew Webb, 1st edition, 2010.
- Biomedical Image Analysis, Rangaraj M. Rangayyan, 1st edition, 2004.

10. General Image Characteristics Lab

Aim:

The aim of the "General Image Characteristics Lab" course is to provide students with hands-on experience and practical skills in analyzing and manipulating various image characteristics. This course will enable students to understand and apply fundamental concepts of medical imaging, ensuring they can optimize image quality for clinical and research purposes.

Objectives:

1. **Practical Understanding of Image Representation:** Students will learn to work with pixels, bytes, field-of-view, and image matrix through practical exercises, gaining insight into how these components affect image quality and interpretation.
2. **Application of Grayscale and Color Imaging:** Students will develop the skills to manipulate and optimize grayscale and color images, understanding the implications of spatial frequency, bit-depth, and aliasing on image quality.
3. **Mastering Image Reconstruction Techniques:** Through lab experiments, students will explore various reconstruction techniques, such as back projection and filtered back projection, enhancing their ability to create accurate and high-resolution images.
4. **Quantitative Image Analysis:** Students will engage in hands-on activities to measure and analyze object size, shape, texture, motion, and flow in images, using quantitative methods to enhance their analytical capabilities.
5. **Integration of Advanced Imaging Techniques:** Students will experiment with multi-modal and time-resolved imaging, as well as artificial intelligence tools, to understand the integration of these techniques in improving diagnostic accuracy.

Course Content:

- **Image Representations:** Practical exercises on pixels, bytes, field-of-view, and the image matrix, Grayscale and color image manipulation.
- **Spatial Frequency and Frequency Space:** Understanding and applying concepts of spatial frequency and frequency space in image processing.
- **Image Reconstruction:** Hands-on experience with back projection, filtered back projection, and iterative reconstruction methods.
- **Quantitative Analysis and Measurement:** Techniques for measuring object size, shape, texture, motion, and flow, Analysis of image overlays, color maps, and vectors.
- **Advanced Imaging Techniques:** Multi-modal and time-resolved imaging, Use of artificial intelligence, machine learning, and deep learning in image enhancement and analysis.

Learning Resources

Textbooks

- The Essential Physics of Medical Imaging, Jerrold T. Bushberg, J. Anthony Seibert, Edwin M. Leidholdt Jr., and John M. Boone, 4th edition, 2020.
- Machine Learning for Medical Image Analysis, S. Kevin Zhou, Hayit Greenspan, and Dinggang Shen, 1st edition, 2017.
- Digital Image Processing, Rafael C. Gonzalez and Richard E. Woods, 4th edition, 2018.
- Introduction to Medical Imaging: Physics, Engineering and Clinical Applications, Nadine Barrie Smith and Andrew Webb, 1st edition, 2010.
- Biomedical Image Analysis, Rangaraj M. Rangayyan, 1st edition, 2004.

11. Non-Ionizing Radiations in Diagnostic Imaging

Aim:

The aim of the "Non-Ionizing Radiations in Diagnostic Imaging" course is to provide a comprehensive understanding of the principles, technology, and applications of non-ionizing radiation in medical imaging, focusing on magnetic resonance and ultrasound. This course aims to equip students with the knowledge and skills necessary to optimize the use of these imaging modalities in clinical practice, ensuring high-quality diagnostic information while maintaining patient safety.

Objectives:

1. Understanding Magnetic Resonance Imaging (MRI) Principles: Students will learn the underlying technology and physics of MRI, including magnetic fields, nuclear magnetism, and resonance, to understand how these principles are applied in diagnostic imaging.
2. Exploring MRI Techniques and Sequences: Students will gain knowledge of various MRI pulse sequences, contrast mechanisms, and imaging techniques, including their advantages, disadvantages, and clinical applications.
3. Comprehending Ultrasound Physics and Equipment: Students will study the physics of ultrasound, including sound wave propagation, interactions with matter, and the functionality of ultrasound transducers, to optimize image acquisition and interpretation.
4. Analyzing Image Characteristics and Artifacts: Students will learn to assess image quality and identify artifacts in both MRI and ultrasound images, understanding the factors affecting spatial resolution, signal-to-noise ratio, and image contrast.
5. Ensuring Safety and Quality in Imaging: Students will understand the safety considerations, bioeffects, and regulatory issues associated with MRI and ultrasound, including the management of potential risks and adherence to quality assurance protocols.

Course Contents

Magnetic Resonance and Equipment:

- **Underlying Technology and Physics Principles:** Magnetism and magnetic fields, Magnetic susceptibility (diamagnetic, paramagnetic, ferromagnetic), Magnetic fields (B), Units for magnetic field strength, Magnetic dipole, Magnetic moment, Nuclear magnetism (protons and biologically relevant nuclei), Magnetic moment interaction with an external field (B0), Alignment (low-energy and high-energy states), Precession frequency, Larmor equation and resonance, Net magnetization due to B0, Equilibrium magnetization (M0), Longitudinal magnetization (Mz), Transverse magnetization (Mxy), Proton density (spin-density), Field strength dependence.

- **Nuclear Magnetic Resonance and Excitation:** Radiofrequency (RF) field (B1), Flip angle, Free-induction decay (FID), Magnetic resonance signal properties, Proton density (spin density), (Transverse) relaxation, Intrinsic spin-spin interactions, Transverse magnetization decay, Relative tissue T2 values ("long" vs. "short"), T2* relaxation, Dependence on field inhomogeneity, Susceptibility induced dephasing (e.g., tissue-air interfaces), T1 (longitudinal) relaxation, Spin-lattice interactions, Longitudinal recovery, Relative tissue T1 values ("long" vs. "short"), Field-strength dependence.
- **Pulse Sequences and Contrast Mechanisms:** Pulse sequence parameters (TR, TE, flip angle, inversion time), Spin-echo (SE) pulse sequence, SE signal intensity dependence on TE and TR, SE contrast (T1, proton density, T2), Inversion-recovery spin-echo pulse sequence, Short-Tau inversion-recovery (STIR), Fluid-attenuated inversion-recovery (FLAIR), Gradient-echo pulse sequence, Types of gradient-echo pulse sequences (steady state, spoiled), Advantages and disadvantages, Signal-intensity and effect of flip angle, Spoiling (RF and gradient), Gradient echo contrast (T2*/T1, T2*, and T1 weighting), Echo-planar (EPI), Single-shot method, Multi-shot method, T2* contrast, Fast or turbo spin-echo, Echo train length and spacing, Effective TE, Contrast (T2 and T1 weighting).
- **Spatial Localization:** Slice selection, Phase encoding, Frequency encoding, Multi-slice acquisition, 2D and 3D acquisitions, Pulse sequence timing diagrams, Factors that affect acquisition time, Two-dimensional Fourier transform (2DFT) image reconstruction, k-space formalism and MR image reconstruction, Methods of "filling k-space".
- **MR Instrumentation:** Static magnetic field (B0) systems, Types of magnets, Fringe field, Main magnetic field shielding (fringe field reduction), Gradient field subsystem, Gradient coil geometry (X, Y, and Z), Gradient strength (mT/m), Slew-rate: specification (mT/m/s), Eddy currents and effects on gradient performance, Shim coils, RF transmitter (B1) subsystem, RF-pulse bandwidth, Control of flip angle, Multi-transmit benefits, RF receiver subsystem, Receive bandwidth, Parallel (and phased-array) receive channels, RF coils, Transmit-and-receive vs. receive-only coils, Surface coils and phased-array coils, Effective use.
- **Paramagnetic and Other Contrast Agents:** Suppression methods and effects, Spatial, Chemical (e.g., fat, silicone), Hybrid sequences (SPIR, SPAIR), Inversion recovery, Dixon method and opposed phase.
- **Special Acquisition Techniques:** MR angiography (2D and 3D) techniques, Phase-contrast techniques, Flow compensation vs. spatial saturation, Contrast enhanced MRA, Magnetization transfer, Diffusion and perfusion, Diffusion-weighted imaging (DWI), Apparent diffusion coefficient (ADC), Diffusion-tensor imaging (DTI), Dynamic susceptibility contrast perfusion (T2*), Parallel imaging MRI (acceleration and SNR), Cardiac imaging, Susceptibility weighted imaging (SWI), Breast MRI.
- **Image Characteristics and Artifacts:** Factors affecting spatial resolution, Field-of-view (FOV), Receiver (sampling) bandwidth, Slice thickness, Image matrix dimensions, Factors affecting signal-to-noise ratio (SNR), Voxel size, Signal averages, Receiver (sampling)

bandwidth, Magnetic field strength, Slice "cross-talk", Reconstruction algorithms, RF coils, Pulse sequence specific effects, Parallel imaging acceleration factors, Saturation and flow, 3D vs. 2D, Tradeoffs among spatial resolution, SNR, and acquisition time, Factors affecting image contrast, Proton density, T1, T2, Susceptibility, Blood flow and blood products, Contrast media, Artifacts, Patient-based (motion, etc.), k-space (spike, etc.), Equipment-based (inhomogeneity, etc.), Acquisition parameter-based (Gibbs ringing, etc.), High-speed imaging artifacts (e.g., echo-planar distortion, etc.), Parallel imaging artifacts, Flow-related artifacts.

- **Safety, Quality Management, and Regulatory Issues:** Safety and bioeffects, Static magnetic field, Fringe field, and spatial gradients fields, Projectile hazards, Effects on implanted devices, FDA limits, RF field, Biological effects (e.g., tissue heating and other), RF heating of conductors and potential burns, Specific absorption rate (SAR), Root mean square RF transmit (B1+rms) and specific, Reducing RF heating effects, Gradient field, Biological effects, Including peripheral nerve stimulation, Sound pressure level ("noise") issues, Limits, Gadolinium-based contrast agents, Nephrogenic systemic fibrosis, Applied MRI safety, Screening patients and healthcare workers, MR safety systems and superconducting magnet "quench" systems, Current risk vs. benefit guidance for pregnant patients and staff, MR safety labeling, Magnet system siting, Magnetic and RF field shielding, Faraday cage, Accreditation and quality improvement, MR quality assurance.

Ultrasound Physics and Equipment:

- **Underlying Technology and Physics Principles:** Basic sound wave concepts, Sound wave propagation, Definition of sound and ultrasound, Properties of longitudinal and transverse waves, Sound wave properties, Wavelength, Frequency, Period, Speed, and Velocity, Density and pressure changes in materials, Particle motion and particle velocity, Compressibility and elasticity, Dependence of sound speed on medium and properties, Power and intensity, Decibel scale, Relationship between intensity and pressure.
- **Interactions of Ultrasound Waves with Matter:** Acoustic impedance, Relationship to density, Speed, and compressibility, Impedance changes at tissue interfaces, Reflection, Refraction, and Transmission, Role of impedance, Reflection coefficient, Normal and oblique incidence, Specular and diffuse reflection, Transmission, Scattering, Absorption, and Attenuation, Hyperechoic, Hypoechoic, Isoechoic, and Anechoic, Relationship to frequency and scattered size, Rayleigh scattering (blood cells), Constructive and destructive interference, Speckle, Attenuation causes and its relationship to sound properties, Attenuation coefficients.
- **Transducer Components and Arrays:** Piezoelectric materials, Transducer construction and operation, Resonance and non-resonance (multifrequency) transducers, Linear and curvilinear arrays, Phased arrays, Annular arrays, 1.5D, 2D, and 3D arrays, Intra-cavitary transducers, Intra-vascular transducers, Beam propagation patterns, Near and far fields, Focused transducers, Side and grating lobes, Transducer array beam formation and

focusing, Linear and sector scanning, Transmit and receive focusing, Beam steering, Beam shaping, Effective use.

- **Pulse-Echo Imaging:** Pulse-repetition period, Frequency, and duty cycle, Field of view and maximum depth, Frame rate, Image data acquisition, Signal acquisition process, Time-gain (or depth-gain) compensation.
- **2D-Image Display and Processing:** Display modes, A-mode, B-mode, and M-mode, Image frame rate, Depth setting, Transmit focal zones, Sector size and line density, Image processing, Pre-processing and post-processing, Noise and speckle reduction, Distance, area, and volume measurements.
- **Doppler Ultrasound:** Doppler theory, Spectral analysis, Flow dynamics (e.g., laminar and plug), Continuous wave (CW) Doppler, Pulsed Doppler, Duplex scanning, Color flow imaging, Power Doppler.
- **Special US Imaging:** Compound imaging, Harmonic imaging, Three-dimensional (3D) imaging, Time-dependent imaging (4D), Elastography.
- **Image Characteristics and Artifacts:** Image quality metric, Spatial resolution: axial, lateral, elevational, Temporal resolution, Image contrast, Noise, CNR, US image artifacts, Transducer (e.g., grating lobes, etc.), Propagation (e.g., shadowing, ring down, etc.), Doppler (e.g., twinkle, flash, flow ambiguity, etc.).
- **US Safety, Quality Management, and Regulatory Issues:** Mechanisms and limits for bioeffects, Heating, Cavitation, Thermal indices (TI), Mechanical index (MI), Acoustic power, Intensity measures of ultrasound energy deposition, Spatial average/temporal average intensity ISATA, Spatial peak/temporal average intensity ISPTA, Spatial peak/pulse average intensity ISPPA, Spatial peak/temporal peak intensity, Pregnant patient and pediatric protocols, Acceptable thermal index of bone (TIB) and thermal index of cranial bone (TIC) limits, Current clinical statements on ultrasound safety, US QC and QA.

Learning Resources

Textbooks

- International Atomic Energy Agency, Diagnostic Radiology Physics: A Handbook for Teachers and Students, IAEA, Vienna (2014).
- BUSHBERG, J.T., SEIBERT, J. A., LEIDHOLDT Jr, E.M. and BOONE, J. M., The Essential Physics of Medical Imaging, 3rd Edition, Wolters Kluwer, Philadelphia (2012).
- DENDY, P.P., HEATON, B., Physics for Diagnostic Radiology, 3rd Edition, CRC Press, USA (2011).
- SAMEI, E., PECK, D., Hendee's Physics of Medical Imaging, 5th Edition, Wiley-Liss, New York (2019).
- International Atomic Energy Agency, Radiation Protection and Safety in Medical Uses of Ionizing Radiation: Specific Safety Guide No. SSG46, IAEA, Vienna (2018).
- Khan's The Physics of Radiation Therapy, Sixth Edition by Faiz M. Khan Ph.D. (Author), John P. Gibbons Ph.D. (Author), (2019)

- Johns and Cunningham's The Physics of Radiology 4th Edition by Eva Bezak (Author), Alun H Beddoe (Author), Loredana G Marcu (Author), Martin Ebert (Author), Roger Price (Author) (1983).
- Radiation Oncology Physics: A Hand book for Teachers and Students, International Atomic Energy Agency, Vienna, 2005

Reference Books

- Introduction to Medical Imaging Physics, Engineering and Clinical Applications, Nadine Barrie Smith and Andrew Webb Published in the United States of America by Cambridge University Press, New York, 2010.

Other Resources (Online Resources or others)

- European Medical Radiation Learning Development (EMERALD): http://www.emerald2.eu/emerald_index.html
- Medical physics encyclopedia and multilingual dictionary: http://www.emitel2.eu/emitwwwsql/index-login.aspx
- Sprawls, P.: http://www.sprawls.org/resources/
- Ultrasound Imaging resources, Ultrarad: http://www.lultrarad.com

12. Ionizing Radiations in Diagnostic Imaging

Aim:

The aim of the "Ionizing Radiations in Diagnostic Imaging" course is to provide students with a comprehensive understanding of the principles, technology, and safety measures involved in diagnostic imaging using ionizing radiations, such as general radiology, computed tomography (CT), and nuclear medicine. The course will equip students with the knowledge and skills needed to operate and evaluate imaging equipment, interpret imaging results, and adhere to radiation safety standards.

Objectives:

- Understanding Radiology Physics and Equipment: Introduce the fundamental physics and technology of radiology equipment, including X-ray production and detectors.
- Operating X-ray Equipment: Familiarize students with the components and operational principles of X-ray equipment, such as the X-ray tube and generators.
- Exploring Computed Tomography (CT): Provide a comprehensive understanding of CT scanner components, data acquisition methods, image reconstruction, and patient dose considerations.
- Nuclear Medicine and PET: Explore the technology and principles of nuclear medicine and PET, focusing on radionuclide decay and quality control.
- Ensuring Radiation Safety: Instruct on radiation protection measures, facility design considerations, and regulatory compliance in diagnostic imaging settings.

Course Contents

- **General Radiology Physics, Equipment and Detectors** X-ray Production, Bremsstrahlung, Characteristic Radiation, Production of X-rays, X-ray Intensity and Dose, Electron Energy, Target Material, Filtration, Spectrum and Beam Quality, X-ray Tube, Cathode, Filament, Focusing Cup, Filament Current and Tube Current, Anode, Composition, Configurations (e.g., Angulation, Stationary vs. Rotating), Line-focus Principle, Focal Spot, Heel Effect, Off-focus Radiation, Tube Heating and Cooling, Applications, Mammography, Radiography and Fluoroscopy (R&F), Interventional Fluoroscopy, Mobile X-ray, Dental, Generators, High frequency, Technique Factors, Tube Voltage (kV), Tube Current (mA), Exposure Time, Automatic Exposure Control (AEC), Technique Charts, X-ray Beam Modification, Beam Filtration, Inherent, Added (Al, Cu, Mo, Rh, Ag, other), Minimum HVL, Shaped Filters, Collimators, Field Size Limitation, Light Field and X-ray Field Alignment, Influence on Image Quality and Dose, Beam Shaping in IR.
- **Computed Tomography** Component of a CT scanner, Data acquisition, Axial/sequential mode, Helical/spiral mode, Cine/perfusion mode, Shuttle mode, CT fluoroscopy, Gantry tilting, Scan angular range, CBCT, Image reconstruction, Image manipulation, Image quality, Image noise, Image contrast, CNR, Spatial resolution, Temporal resolution, Scatter,

Slice thickness, DQE, Detector dynamic range, Detector element size, Focal spot size, Patient dose from CT, Pediatric CT.

- **Nuclear Medicine Physics and Equipment:** Nuclear Medicine and Positron Emission Tomography (PET), Underlying Technology and Physical Principles, Radionuclide Decay, Nuclear Transformation, N/Z Ratio and Nuclear Stability, Beta (Negative Electron) Decay, Positron (Positive Electron) Decay, Electron Capture, Isomeric Transition, Alpha Decay, Gamma and Internal Conversion, Decay Modes of Commonly Used Radionuclides, Radioactive Equilibrium, Transient and Secular Radioactivity, Definition of Radioactivity, Units, Decay Constant and Decay Rate, Decay Equation, Half-life (Physical, Biological and Effective), Specific Radioisotope Production, Reactor, Fission Products, Neutron-Activation Products, Molybdenum Production Process, Cyclotron, Principle of Operation, An overview of medical cyclotron used for production of radioisotopes, Positron Emitting Isotopes, Radionuclide Generators, 99Mo – 99mTc, Elution and Quality Control, Radiopharmaceuticals, Preparation, Diagnostic Reference Levels for Clinical Studies, Uptake, Distribution, and Clearance Kinetics, Quality Assurance and Quality Control Procedures, Specific Activity, Tracer Concept.
- **Scintillation Camera** Clinical Utilization, Camera Design, Crystal Parameters, Spatial Localization, Anger camera principles, Energy Discrimination, Camera Corrections, Collimator Types and Characteristics, Parallel Hole, Pinhole, and Other Geometries, Sensitivity, Resolution, Energy Specification (e.g., LEHR, ME, HE), Image Acquisition, Static, Dynamic, Gated, List-Mode, Count Rate and Administered Activity Considerations, Image Processing, Normalization and Subtraction, Region of Interest (ROI), Time–Activity Curves, Spatial Filtering, Gamma Camera Quality Control (Extrinsic and Intrinsic), Uniformity, Spatial Resolution, Energy Resolution, Spatial Linearity, Sensitivity, Count-Rate Performance, Dead-Time.
- **PET Scanners** Detector Materials, Detector Configuration (e.g., Blocks, Rings, 2D/3D, etc.), Coincidence Detection, Lines of Response (LOR), Trues, Scatter, and Random Coincidence Events, Time-of-Flight, Cardiac and Respiratory Gating, Attenuation Correction, Computed Tomography, Mathematical Corrections (e.g., Chang's Correction), Image Reconstruction and Filtering, Filtered Back Projection, Iterative Reconstruction (e.g. MLEM, OSEM), Sensitivity and Resolution, Matrix Size, Resolution Recovery (PSF Reconstruction).
- **Effective Use** Clinical Quantitative Imaging, Thyroid and Parathyroid, Renal, Cardiac (Ejection Fraction, Myocardial Perfusion), Ventilation Perfusion (VQ), Multi-energy Imaging, Gall Bladder (Ejection Fraction), Gastric Emptying.
- **Single Photon Emission Computed Tomography (SPECT) and SPECT/CT** Clinical Utilization, Mechanisms of Operation, Single- and Multi-Head Units, Rotational Arc, Continuous Motion, Step-and-Shoot, Noncircular Orbits, Number of Steps (Views and Frames), Positron Emission Tomography (PET) and PET/CT, Clinical Utilization, Oncology (e.g. FDG), Neurology (e.g. Florbetapir), Cardiac (e.g. Rb), Attenuation Correction, Standardized Uptake Value (SUV) and Contributing Factors, Image Characteristics and Artifacts, Spatial

Resolution, Sensitivity, Noise, Count Rate and Administered Activity Considerations, Artifacts, NM Instrumentation Sources (e.g., Non-uniformity, Collimator, Improper Energy Peaking, etc.), NM Patient Sources (e.g., Attenuation Correction, Motion, Foreign Object, etc.), PET Instrument Sources (e.g., Block Loss, Misregistration, etc.), PET Patient Sources (e.g., High Serum Glucose, Motion, Attenuation Correction, etc.).

- **Safety, Quality Management and Regulatory Issues** Radiation Protection, Facility Design, Transport and Receiving of Radioactive Sources, Transportation Index, Storage, Labeling and Logs, Structural Shielding (No Calculations), Occupational Exposure, Protective Measures, Personal Monitoring, Shielding of Radionuclides (Gamma, Betas), Exposure from Patients, Release criteria, Radioactive Material Spills, Radio-pharmacy, Wipe Tests and Daily Surveys, Surface Contamination Doses, Radioactive Waste Records, Internal Dose Assessment, Effective Half-Life, Medical Internal Radiation Dose (MIRD) Formalism, Regulatory and Accreditation Requirements, Radiation Emergencies and Disaster Plans.
- **Radiation Detection Instrumentation** Gas-Filled Detectors, Mechanisms of Operation, Applications and Limitations, Survey Meters (e.g., GM Counter, Ionization Chamber), Dose Calibrator, Quality Control, Scintillation Detectors, Mechanisms of Operation, Applications and Limitations, Pulse-Height Spectroscopy, Thyroid Probe, Photomultiplier Tube (PMT), New Technological Innovations (e.g., Solid State Cameras, Cardiac Gamma Cameras, etc.), Well Counter Quality Control, Solid State Detectors.
- **Nuclear Medicine Therapy** Radiopharmaceuticals, I-131 Sodium Iodide, Y-90 Microspheres, Ra-223 Dichloride, Sm-153 EDTMP, Ac-225, Lu-177, Regulatory Considerations, Clinical Utilization, Written Directive, Patient Safety and Release Considerations, Factors Affecting Public, Staff, and Unintended Patient Dose.
- **Counting Statistics** Poisson Distribution, Propagation of Error (Gross, Net, and Background Counts), Uncertainty, Standard deviation, and Coefficient of Variation.
- **Quality Assurance and Quality Control** QC Phantoms, NM Testing (e.g., Center of Rotation, Uniformity, etc.), PET Testing (e.g., SUV, Uniformity, etc.), CT Registration.

Learning Resources

Textbooks

- International Atomic Energy Agency, Diagnostic Radiology Physics: A Handbook for Teachers and Students, IAEA, Vienna (2014).
- BUSHBERG, J.T., SEIBERT, J. A., LEIDHOLDT Jr, E.M. and BOONE, J. M., The Essential Physics of Medical Imaging, 3rd Edition, Wolters Kluwer, Philadelphia (2012).
- DENDY, P.P., HEATON, B., Physics for Diagnostic Radiology, 3rd Edition, CRC Press, USA (2011).
- SAMEI, E., PECK, D., Hendee's Physics of Medical Imaging, 5th Edition, Wiley-Liss, New York (2019).
- International Atomic Energy Agency, Radiation Protection and Safety in Medical Uses of Ionizing Radiation: Specific Safety Guide No. SSG46, IAEA, Vienna (2018).

- Khan's The Physics of Radiation Therapy, Sixth Edition by Faiz M. Khan Ph.D. (Author), John P. Gibbons Ph.D. (Author), (2019)
- Johns and Cunningham's The Physics of Radiology 4th Edition by Eva Bezak (Author), Alun H Beddoe (Author), Loredana G Marcu (Author), Martin Ebert (Author), Roger Price (Author) (1983).
- Radiation Oncology Physics: A Hand book for Teachers and Students, International Atomic Energy Agency, Vienna, 2005

Reference Books

- Christensen',s Physics of Diagnostic Radiology by Thomas S Curry, 4th Edition, Lippincott Williams & Wilkins, 1990.
- Essentials of Nuclear Medicine Imaging, 6th Edition, F A Mettler, MJ Guibertau, Saunders, 2012.
- Molecular Imaging FRET Microscopy and Spectroscopy Edited by Ammasi Periasamy and Richard N Day, Oxford Press 2005
- Introduction to Medical Imaging Physics, Engineering and Clinical Applications, Nadine Barrie Smith and Andrew Webb Published in the United States of America by Cambridge University Press, New York, 2010.

Other Resources (Online Resources or others)

- European Medical Radiation Learning Development (EMERALD): http://www.emerald2.eu/emerald_index.html
- Medical physics encyclopedia and multilingual dictionary: http://www.emitel2.eu/emitwwwsql/index-login.aspx
- Sprawls, P.: http://www.sprawls.org/resources/

13. Diagnostic Imaging Lab

Aim:

To provide students with practical experience and understanding of the principles, practices, and quality control in both ionizing and non-ionizing diagnostic imaging modalities, focusing on factors affecting image quality and safety.

Objectives:

- To understand the impact of various parameters on X-ray tube output and apply this knowledge to optimize diagnostic imaging practices.
- To develop practical skills in the operation, maintenance, and evaluation of imaging systems in a clinical setting.
- To assess and evaluate image quality in diagnostic imaging across different modalities.
- To master the principles of ultrasound imaging and conduct quality control for accurate and reliable results.
- To familiarize with MRI imaging principles, safety, and quality control procedures to ensure optimal performance.

Course Contents:

- **X-ray Tube Output Dependence:** Half-Value Layer (HVL): Definition, significance, measuring HVL, effect on X-ray beam quality, Tube Voltage (kV): Effect on beam penetration, image contrast, practical exercises in adjusting and measuring tube voltage, Tube Current (mA): Impact on X-ray intensity, image noise, procedures for measurement and adjustment, Exposure Time: Influence on image exposure, techniques for optimization, managing motion artifacts, Beam Filtration: Purpose, types of filters, measurement, and effect on image quality, Distance: Inverse square law, implications for exposure, practical measurement, and adjustment exercises.
- **Image Quality Assessment:** Contrast: Definition, factors affecting contrast, techniques for evaluation, Resolution: Spatial resolution importance, methods for assessment, and improvement, Modulation Transfer Function (MTF): Definition, role in image quality, practical measurement, and interpretation.
- **Imaging Principles of Ultrasound:** QC of ultrasound: Methods for quality control, ensuring accurate and reliable imaging results, Measurement of Intensity, Power: Techniques for measuring and understanding their impact on image quality.
- **Imaging Principles of MRI:** Basic Pulse Sequences: Common imaging options, practical exercises in MRI imaging techniques, Radiofrequency and Gradient Coil Design: Specifications, understanding their role in imaging, Siting and Safety Aspects of MRI: Safety guidelines, regulatory standards, practical safety exercises, MRI Acceptance Testing, QC, and Accreditation: Procedures to ensure compliance and optimal performance.

Learning Resources

Textbooks

- International Atomic Energy Agency, Diagnostic Radiology Physics: A Handbook for Teachers and Students, IAEA, Vienna (2014).
- BUSHBERG, J.T., SEIBERT, J. A., LEIDHOLDT Jr, E.M. and BOONE, J. M., The Essential Physics of Medical Imaging, 3rd Edition, Wolters Kluwer, Philadelphia (2012).
- Khan's The Physics of Radiation Therapy, Sixth Edition by Faiz M. Khan Ph.D. (Author), John P. Gibbons Ph.D. (Author), (2019)
- Johns and Cunningham's The Physics of Radiology 4th Edition by Eva Bezak (Author), Alun H Beddoe (Author), Loredana G Marcu (Author), Martin Ebert (Author), Roger Price (Author) (1983).

Reference Books

- DENDY, P.P., HEATON, B., Physics for Diagnostic Radiology, CRC Press, USA (2011).
- SAMEI, E., PECK, D., Hendee's Physics of Medical Imaging, Wiley-Liss, New York (2019).
- International Atomic Energy Agency, Radiation Protection and Safety in Medical Uses of Ionizing Radiation: Specific Safety Guide No. SSG46, IAEA, Vienna (2018).

Other Resources (Online Resources or others)

- European Medical Radiation Learning Development (EMERALD): http://www.emerald2.eu/emerald_index.html
- Medical physics encyclopedia and multilingual dictionary: http://www.emitel2.eu/emitwwwsql/index-login.aspx
- Sprawls, P.: http://www.sprawls.org/resources/

14. Research Methodology and Professional Development

Aim:

To equip students with a comprehensive understanding of ethical principles, professionalism in medical practice, and essential research skills necessary for conducting and evaluating scientific research.

Objectives:

1. To understand and apply ethical principles in clinical and research settings.
2. To develop professionalism in clinical governance and quality management.
3. To enhance skills in scientific communication, research planning, and data analysis.
4. To ensure proper conduct in research and academic writing, including issues related to authorship and integrity.

Course Contents

- **Ethics:** The World Medical Association Declaration of Helsinki, Basis of clinical trials, Ethics review/ committees, Ethical principles: beneficence, non-maleficence, autonomy (respect), justice (impartiality), prudence (precaution), honesty (transparency), accountability, inclusiveness, etc.
- **Professionalism:** Clinical governance, Quality management, Code of conduct, Management of medical equipment, Conflict of interest, Peer review/ Journal club
- **Presentation skills:** Scientific communication, Techniques of instruction
- **Research Methodology**: Research planning, Literature review, Data gathering and processing, Statistical methods in research, Computational tools and analysis, Critical analysis, Scientific writing, Authorship, integrity, plagiarism

Learning Resources

Textbooks

- JURAN, J. M., and DE FEO, J., Juran's quality handbook: The complete guide to performance excellence, 6th Edition, McGraw-Hill, New York (2010).
- Research Methodology: A Step-by-Step Guide for Beginners, Third Edition by Ranjit Kumar, SAGE Publications Ltd (2012).

Reference Books

- BEAUCHAMP, T.L., CHILDRESS, J.F., Principles of Biomedical Ethics, 8th Edition, Oxford University Press, UK (2019).
- Research for Medical Imaging and Radiation Sciences, Euclid Seeram, Robert Davidson, Andrew England, Mark F. McEntee, Springer International Publishing, Jan 4, 2022

Other Resources (Online Resources or others)

- AAPM Code of Ethics: https://w3.aapm.org/medical_physicist/ethics.php
- COMP Code of Ethics: https://comp-ocpm.ca/english/about-comp/what-is-medical-physics/code-of-ethics.html#:~:text=1.,public%2C%20and%20co%2Dworkers.
- IAEA Human Health Series No. 25: Code of Ethics for Medical Physicists working in the medical environment

15. Radiobiology

Aim:

The Radiobiology course aims to provide students with a comprehensive understanding of the biological effects of radiation on molecular, cellular, and systemic levels, as well as the implications for tumor radiotherapy and radiation protection.

Objectives:

1. Understanding Radiation Quantities: Students will learn about various radiation quantities used in radiobiology, including dose, effective dose, equivalent dose, Linear Energy Transfer (LET), and Relative Biological Effectiveness (RBE), and their relevance in assessing biological damage and risks.
2. Molecular and Cellular Radiobiology: Students will explore the molecular and cellular mechanisms of radiation damage, including DNA lesions, repair processes, cell death, and survival curves, and understand the concepts of direct and indirect effects, bystander effects, and radiation sensitizers.
3. Systemic and Tissue Reactions: Students will examine the systemic effects of radiation, focusing on tissue and organ reactions, acute radiation syndromes, stochastic effects such as carcinogenesis, mutagenesis, and teratogenesis, and the differences in radiation sensitivity based on age and gender.
4. Radiotherapy and Tumor Response: Students will study the principles of tumor radiotherapy, including tumor growth and response to irradiation, dose fractionation effects, tumor hypoxia, and predictive assays for tumor and normal tissue response, as well as the therapeutic ratio.
5. Radiation Risk and Protection: Students will understand the concepts of radiation risk, including dose-response models, risk communication, and the radiobiological basis of radiation protection, as well as the long-term health consequences of radiation exposure from accidents and low-dose radiation.

Course Contents

- **Radiation Quantities in Radiobiology:** Dose, Effective dose, Equivalent dose, Linear Energy Transfer (LET), Relative Biological Effectiveness (RBE), Radiation Weighting Factors, Tissue Weighting Factors, Biologically effective dose (BED).
- **Molecular and Cellular Radiobiology:** Direct vs. Indirect Effects, Radiation lesions in DNA, Major types of DNA repair, Damage recognition and signaling, Consequences of unrepaired DNA damage: chromosome damage, Radiobiological definition of cell death, Survival curves and models, Cell cycle effects, Relative biological effectiveness (RBE), Cellular repair exemplified in survival curves, Cellular hyper-radiosensitivity (HRS) and induced repair (IRR), Other molecular targets: bystander (epigenetic) effects, Radiation sensitizers, Radiation protectors.

- **Systemic Effects of Radiation:** Tissue and Organs, Whole Body, Population (Age and Gender) Tissue Reactions (Deterministic) Effects: Acute Radiation Syndromes, Hematopoietic, Gastrointestinal, Neurovascular, LD50/60, Skin Effects, Lens Effects, Reproductive Impact.
- **Stochastic Radiation Effects:** Radiation Epidemiological Studies, Carcinogenesis, Radiation-Induced Cancers, Leukemia, Solid Tumors, Spontaneous Rate (Natural Incidence), Latency, Mutagenesis, Teratogenesis, Developmental Effects, Childhood Leukemia, Gestational Sensitivity.
- **Radiation Risk:** Benefit vs. Risk in Radiology, Definition and Communication of Risk (e.g., relative, absolute, etc.), Dose-Response Models, Linear No-Threshold (LNT), Linear-Quadratic, Radiation Hormesis/Adaptive Response.
- **Tumor Radiotherapy:** Tumor growth, Tumor response to irradiation, Dependence of tumor control on dose and tumour size, Dose fractionation effects, Predicting the radiation response of tumors, Tumor hypoxia, Tumor control probability (TCP), Normal tissue response to radiotherapy, Cellular and tissue response, Acute tissue responses, Late tissue responses, Predicting normal tissue response, Therapeutic ratio, Whole body irradiation, Nominal tissue complication probability(NTCP),Time-dose-fractionation, Repair,Repopulation, Redistribution / recruitment, Reoxygenation, Time and dose relationships, Isoeffect curves, The linear quadratic equation and models for isoeffect , Altered fractionation schedules, Predictive assays, Predicting the response of tumors, Predicting normal tissue response, Combined radiation and drug treatments.
- **Clinical Radiobiology of Common Cancers:** Second cancers in radiotherapy patients, Radiobiological basis of radiation protection, Health consequences after total body irradiation from radiation accidents, Long term radiation risks from low radiation doses, Radiation-induced cancer in nuclear weapon survivors, Epidemiological studies in other radiation-exposed populations, Mechanisms of radiation-induced cancer

Learning Resources

Textbooks

- JOINER, M.C., VAN DER KOGEL, A.J., (Eds), Basic Clinical Radiobiology 5th edition, CRC Press (2019).
- HALL, E.J., AND GIACCIA, A. Radiobiology for the Radiologist, Lippincott Williams & Wilkins, Philadelphia, US, 8th Ed. (2018).
- LEHNERT, S., Bimolecular Action of Ionizing Radiation (Series in Medical Physics and Biomedical Engineering), 1st Edition, Taylor and Francis, USA (2007).
- Khan's The Physics of Radiation Therapy, Sixth Edition by Faiz M. Khan Ph.D. (Author), John P. Gibbons Ph.D. (Author), (2019)
- Johns and Cunningham's The Physics of Radiology 4th Edition by Eva Bezak (Author), Alun H Beddoe (Author), Loredana G Marcu (Author), Martin Ebert (Author), Roger Price (Author) (1983).

- Radiation Oncology Physics: A Handbook for Teachers and Students, International Atomic Energy Agency, Vienna, 2005

Reference Books

- INTERNATIONAL ATOMIC ENERGY AGENCY, Radiation Biology: A Handbook for Teachers and Students, Training Course Series, No. 42, IAEA, Vienna (2010).
- ICRP, 2007. The 2007 Recommendations of the International Commission on Radiological Protection. ICRP Publication 103. Ann. ICRP 37 (2-4).

Other Resources (Online Resources or others)

- Radiation Oncology Physics Slides by IAEA
- EMERALD, EMIT, EMITEL
- http://www.sprawls.org/resources/

16. Radiation Dosimetry

Aim: To provide a comprehensive understanding of radiation dosimetry principles, measurement techniques, and calibration procedures essential for accurate dose assessment in medical and research applications.

Objectives:

1. To understand fundamental dosimetric principles and the relationship between different dosimetric quantities.
2. To learn about various radiation dosimeters and their properties.
3. To become proficient in radiation monitoring instruments and their calibration.
4. To apply dosimetry protocols for accurate dose measurement and quality assurance.
5. To gain expertise in beam quality specification and error analysis in dosimetry.

Course Contents

- **Radiological Standards and Traceability:** Overview of Radiological Standards and Traceability.
- **Dosimetric Principles, Quantities & Units:** Introduction, Photon fluence, and energy fluence, Kerma, absorbed dose, stopping power.
- **Relation Between Various Dosimetric Quantities:** Energy fluence and kerma (photon), fluence and dose (electrons), kerma and dose (charged particle equilibrium), collision kerma, and exposure.
- **Cavity Theory:** Bragg-Gray Cavity Theory, Spencer-Attix Cavity Theory, Burlin Cavity Theory.
- **Radiation Dosimeters:** Properties of Dosimeters: Accuracy and precision, linearity, dose rate dependence, energy dependence, directional dependence. Film dosimeter, Luminescence dosimeter, Semiconductor dosimeter, Primary standards.
- **Radiation Monitoring Instruments:** Introduction, Operation quantities for Radiation Monitoring, Area survey meters, properties of survey meter, Individual Monitoring instruments.
- **Calibration of Photon and Electron Beams:** Calorimetry, Fricke Dosimetry, Ionization Chamber Dosimetry, Mean energy expended in the air per ion pair formed.
- **Dosimetry Protocols:** Ionization Chamber-Based Dosimetry Systems, Ionization chambers, Electrometer and power supply, Phantoms. Determination of Absorbed Dose Using Calibrated Ionization Chambers, Air kerma-based protocols, absorbed dose to water-based protocols, Mass-Energy Absorption Coefficient Ratios & Perturbation Correction Factors.
- **Beam Quality Specification:** Beam quality specification for megavoltage photon beams, Beam quality specification for megavoltage electron beams. Calibration of Megavoltage

Photon and Electron Beams Aspects, Stopping power Ratios, Electron Beam, Photon beam.

- **Error and Uncertainty Analysis for Ionization Chamber Measurements:** Estimation and expression of uncertainty in dosimetric measurements.

Learning Resources

Textbooks

- ATTIX, FRANK H., Introduction to Radiological Physics and Radiation Dosimetry. 1st edition, Wiley, USA (1986).
- ROGERS, D.W.O., AND CYGLER, JOANNA, Clinical Dosimetry Measurements in Radiotherapy: AAPM 2009 Summer School, Medical Physics Pub Corp, Madison, USA (2009).
- KNOLL, GLENN F., Radiation Detection, and Measurement.4th Edition, Wiley, USA (2010).
- Khan's The Physics of Radiation Therapy, Sixth Edition by Faiz M. Khan Ph.D. (Author), John P. Gibbons Ph.D. (Author), (2019)
- Johns and Cunningham's The Physics of Radiology 4th Edition by Eva Bezak (Author), Alun H Beddoe (Author), Loredana G Marcu (Author), Martin Ebert (Author), Roger Price (Author) (1983).
- Radiation Oncology Physics: A Hand book for Teachers and Students, International Atomic Energy Agency, Vienna, 2005

Reference Books

- Hand book of Radiotherapy Physics, 1st Edition, P.Mayles, A. Nahum, J-C Rosenwald, Institute of Physics Publishing, 2007.
- The Modern Technology of Radiation Oncology, 2nd Edition, Van Dyke J (Ed.). Medical Physics. Medical Physics Publishing Corporation, 2005, Madison, WI, United States

Other Resources (Online Resources or others)

- Radiation Oncology Physics Slides by IAEA
- EMERALD, EMIT, EMITEL
- http://www.sprawls.org/resources/

17. Radiation Dosimetry Lab

Aim:

To provide hands-on experience in radiation dosimetry, focusing on the calibration of clinical beams, data acquisition for various field sizes, and the use of computerized treatment planning systems.

Objectives:

1. To perform reference dosimetry calibration of clinical beams using established international protocols.
2. To acquire and analyze data for different field sizes and depths in megavoltage photon beams.
3. To determine output factors for different field sizes and measure various dosimetric parameters.
4. To use computerized treatment planning systems for dose calculations and planning.

Course Contents

- Reference dosimetry calibration of clinical beams using an international protocol, e.g. IAEA TRS 398, Small field dosimetry, Data acquisition for different field sizes at different depths of Megavoltage photon and calculation of Output factor, PDD measurement, TPR, TMR & TAR measurement, Quality index, Flatness and Profile measurements, Beam quality index measurement, Data acquisition for different field sizes at different depths of Megavoltage photon and calculation of Output factor, PDD measurement, Rp, R80, & R50 measurement, Effective SSD calculation, Profile measurements, Determination of output factor for asymmetric and symmetric field size using Linac & 60Co data, Computerized treatment planning

Learning Resources

Textbooks

- TRS-398, International Atomic Energy Agency. Vienna, 2000
- ICRU Report 90. Key Data for Ionizing-Radiation Dosimetry: Measurement Standards and Applications. International Commission on Radiation Units and Measurements. Bethesda, MD, USA (2016).
- Khan's The Physics of Radiation Therapy, Sixth Edition by Faiz M. Khan Ph.D. (Author), John P. Gibbons Ph.D. (Author), (2019)
- Johns and Cunningham's The Physics of Radiology 4th Edition by Eva Bezak (Author), Alun H Beddoe (Author), Loredana G Marcu (Author), Martin Ebert (Author), Roger Price (Author) (1983).
- Radiation Oncology Physics: A Hand book for Teachers and Students, International Atomic Energy Agency, Vienna, 2005

Reference Books

- Hand book of Radiotherapy Physics, 1st Edition, P.Mayles, A. Nahum, J-C Rosenwald, Institute of Physics Publishing, 2007.

Other Resources (Online Resources or others)

- Radiation Oncology Physics Slides by IAEA
- EMERALD, EMIT, EMITEL
- http://www.sprawls.org/resources/

18. Radiotherapy Physics, Equipment and Methods

Aim:

To provide an in-depth understanding of radiotherapy physics, including the principles of oncology, equipment and techniques used in radiation therapy, quality management, and radiation protection.

Objectives:

1. To understand the fundamentals of oncology and the principles guiding cancer treatment.
2. To become proficient in the operation and application of various radiotherapy equipment and techniques.
3. To gain knowledge in quality management systems and their application in radiotherapy.
4. To learn about different radiotherapy techniques including external beam radiotherapy, brachytherapy, and unsealed source therapy.
5. To understand radiation protection principles and manage uncertainty in radiotherapy.

Course Contents

- **Fundamentals of Oncology:** Principles of oncology: epidemiology, etiology, biology of cancers, localization of primary tumors, dissemination pathways, treatment modalities, Tumor classification, Evidence-based practice in oncology, Developments in oncology
- **Beam Shaping and Quality Management in Radiotherapy:** Beam shaping, Quality management systems, Quality audit, analysis, and improvements
- **External Beam Radiotherapy:** Treatment and imaging equipment: kV X-ray units (conventional), Cobalt units, Linear accelerators and other systems for MV X-ray and electron beams, Practical designs for production and control of static and dynamic clinical beams, Technology for imaging in radiation therapy, Hadron therapy units, Simulators: conventional and CT simulators, virtual simulators, Standard CT and other imaging systems for localization (MRI, PET, etc.), Clinical dosimetry of conventional treatment beams: In air and in phantom characteristics of clinical beams, Definition of 'reference conditions' in fixed SSD and isocentric approaches, Definition of terminology (e.g., PDD, TMR, TPR, etc.), Beam quality specification, Absolute and reference dosimetry, absorbed dose in reference conditions: national and international protocols, Relative dosimetry: Central axis dose distribution in water, Electron beam characteristics, range, and energy parameters, Output factors: effects of head scatter and phantom scatter, dependence on treatment parameters, 3D dose distribution: beam profiles (penumbra region, flatness, symmetry, etc.), Effects of beam modifiers: hard wedges, virtual wedges, compensators, etc., Requirements and methods of data acquisition for treatment planning: Patient data acquisition, Patient position and immobilization, Imaging acquisition, image registration, and image fusion, Multiple image sets: handling and analysis, Quality assurance of

imaging processes, Target volume and critical organ localization, Volume growing and margin evaluation

- **Treatment Planning:** Specification of dose and volumes, margin decisions, including international recommendations (e.g., ICRU 50, 62, 83); GTV, CTV, PTV, etc., Principles of treatment planning: manual and computer-supported, Monitor units calculation and systems: SSD and isocentric approaches, Treatment planning systems, including hardware, implementation, input, output, and networking, Virtual simulation and tools: BEV, DRR, Treatment planning algorithms: 1D, 2D, and 3D algorithms, Treatment planning optimization and evaluation: uniformity criteria and constraints, DVH, biological indices (TCP, NTCP), IMRT planning (including ICRU 83), Recording and reporting according to international recommendations, Archiving and back-up.
- **Radiotherapy Techniques:** Conventional techniques: use of wedges, bolus, compensators; beam shaping, beam combinations: weighting and normalization, field matching, rotational techniques, Special Techniques in Radiation Oncology: Rationale for special techniques and required physics resources and requirements, Examples of special techniques (e.g., Total Body Irradiation, Total Skin Electron Therapy, Intraoperative Radiotherapy, Stereotactic Radiosurgery, Stereotactic Body Radiation Therapy, radionuclide therapy)
- **Treatment Verification:** Patient alignment and set-up on the simulator for verification and on treatment machines, Set-up and movement tracking systems, Imaging at the treatment unit (e.g., portal imaging), Optimization of set-up and use of systems, Geometrical accuracy, reproducibility, and methods of assessment, In vivo dosimetry, IMRT verification, Record and verify systems, Multimodality imaging for treatment planning
- **Quality Assurance:** Equipment specifications, commissioning and QC of treatment units, treatment planning systems, imaging systems in RT, dosimetry systems, networks, National and international recommendations and local protocols, QA of treatment processes, Verification, checking, and QA of individual patients' treatment plans and MU calculations
- **Brachytherapy:** Equipment: Sources: radionuclide types and source design, Applicators, After-loading systems: low dose rate (LDR), high dose rate (HDR), pulsed dose rate (PDR), Source calibration equipment, Imaging systems for brachytherapy, Source Specification: Quantities and units: activity, reference air kerma rate (RAKR), exposure rate, etc., 'Source strength' specification according to national and international protocols, including IAEA recommendations, Dosimetry measurement methods, Treatment Techniques and Methods: Permanent and temporal implants, Standard applications, Classical implantation and dose calculation systems (LDR), e.g., interstitial, the 'Paris System' and intracavitary, the 'Manchester System', Extension to other dose rate categories: HDR, PDR, Special brachytherapy techniques (e.g., permanent prostate seeds, stereotactic brain implants, eye plaques, intravascular), Treatment Planning and Dose Calculation: General formalisms, including TG 43 (AAPM), General and points structure of brachytherapy

planning systems, Data configuration and TPS set-up, Source and points position reconstruction algorithms: radiographic films, CT, and other image-based algorithms, Dose calculation algorithms; optimization algorithms for HDR, PDR, Treatment planning optimization and evaluation, uniformity criteria and constraints, Specification of dose and volumes according to national and international protocols, including ICRU recommendations, Quality Assurance: Equipment specifications, commissioning, and QC of after-loading equipment (LDR, HDR, PDR), treatment planning systems (reconstruction algorithms and calculation algorithms), sources and applicators, imaging systems in BT, dosimetry systems, networks, etc., National and international recommendations and local protocols, QA of the whole treatment brachytherapy process, Verification, checking, and QA of individual patients' treatment plans

- **Unsealed Source Therapy:** Choice of radionuclide; physical properties, Radiobiological considerations, Dosimetry techniques, MIRD, Targeted therapies: dosimetric protocols, General procedures in the management of unsealed source therapy, Specific therapy procedures
- **Radiation Protection for Ionizing Radiation:** Radiation risk assessment: Biological basis of radiological risk, The effects of radiation on the embryo and fetus, leukemogenesis and carcinogenesis, genetic and somatic hazards for exposed individuals and populations, Scientific basis of radiation protection, Quantities and Units in Radiation Protection: Basic principles of dose limitation, Deterministic and stochastic effects, Justification, Optimization: ALARA principle, Dose limits (workers, population), Radiation monitoring: classification of areas, personal monitoring, Administration and Organization of Radiation Protection: National and international rules and organizations, National and international legislation, Design and facilities including treatment rooms, imaging rooms, sealed and non-sealed source storage, Management of radiation safety, including hazard assessment, contingency plans, Accidents in radiotherapy, Radioactive material management, transport, and waste disposal, Patient protection
- **Uncertainty in Radiotherapy:** Measurement theory, Sources of uncertainty, Management of uncertainty, Tolerance and action levels

Learning Resources

Textbooks

- Khan's The Physics of Radiation Therapy, Sixth Edition by Faiz M. Khan Ph.D. (Author), John P. Gibbons Ph.D. (Author), (2019)
- Johns and Cunningham's The Physics of Radiology 4th Edition by Eva Bezak (Author), Alun H Beddoe (Author), Loredana G Marcu (Author), Martin Ebert (Author), Roger Price (Author) (1983).
- Radiation Oncology Physics: A Hand book for Teachers and Students, International Atomic Energy Agency, Vienna, 2005

- Hand book of Radiotherapy Physics, 1st Edition, P.Mayles, A. Nahum, J-C Rosenwald, Institute of Physics Publishing, 2007.
- BALTAS, D., SAKELLIOU, L., ZEMBOGLOU, N., The Physics of Modern Brachytherapy for Oncology, CRC Press (2007).
- INTERNATIONAL ATOMIC ENERGY AGENCY, Radiation Protection and Safety in Medical Uses of Ionizing Radiation: Specific Safety Guide No. SSG46, IAEA, Vienna (2018).

Reference Books

- ICRU Report 50. Prescribing, Recording, and Reporting Photon Beam therapy. International Commission on Radiation Units and Measurements. Bethesda, MD, USA (1993).
- ICRU Report 62. Prescribing, Recording, and Reporting Photon Beam Therapy (Supplement to ICRU Report 50). International Commission on Radiation Units and Measurements. Bethesda, MD, USA (1999)
- ICRU Report No. 71. Prescribing, Recording, and Reporting Electron Beam Therapy. International Commission on Radiation Units and Measurements. Bethesda, MD, USA (2004).
- ICRU Report 83. Prescribing, Recording, and Reporting Photon Beam Intensity Modulated Radiation Therapy (IMRT). International Commission on Radiation Units and Measurements. Bethesda, MD, USA (2010).
- ICRU Report 91. Prescribing, Recording, and Reporting of Stereotactic Treatments with Small Photon Beams. International Commission on Radiation Units and Measurements. Bethesda, MD, USA (2019).

Other Resources (Online Resources or others)

- Radiation Oncology Physics Slides by IAEA
- EMERALD, EMIT, EMITEL
- http://www.sprawls.org/resources/

19. Radiotherapy Physics, Equipment and Methods Lab

Aim:

To provide hands-on experience with the equipment and techniques used in radiotherapy, focusing on beam shaping devices, beam calibration, and dosimetry systems.

Objectives:

1. To familiarize students with various beam shaping devices used in radiotherapy.
2. To perform beam calibration for different types of radiation using international dosimetry protocols.
3. To conduct cross-calibration of ionization chambers for megavoltage electron beams.
4. To calibrate and verify dosimetry systems, including ion chambers and electrometers.

Course Contents

- Observation and describing of different types of beams shaping devices, For photon: block, wedge, shielding, compensator; For Electron: applicator, MLCs, immobilizing devices, wedge, shielding Beam calibration using international dosimetry protocol IAEA for a) Co-60, b) Photons c) electrons Cross calibration of Electron ionization chamber for megavoltage Electron beam using Farmer & Marcus chamber.
- Calibration of dosimetry system (ion chamber, electrometer using PTW dosimetry system).

Learning Resources

Textbooks

- Practical Radiotherapy Planning Fourth Edition, By Ann Barrett, Jane Dobbs, Tom Roques, 2009
- Khan's The Physics of Radiation Therapy, Sixth Edition by Faiz M. Khan Ph.D. (Author), John P. Gibbons Ph.D. (Author), (2019)
- Johns and Cunningham's The Physics of Radiology 4th Edition by Eva Bezak (Author), Alun H Beddoe (Author), Loredana G Marcu (Author), Martin Ebert (Author), Roger Price (Author) (1983).
- Radiation Oncology Physics: A Hand book for Teachers and Students, International Atomic Energy Agency, Vienna, 2005

Reference Books

- PODGORSAK, E. B., Radiation Physics for Medical Physicists (Biological and Medical Physics, Biomedical Engineering), 2nd Edition, Springer, New York, USA (2010).
- Hand book of Radiotherapy Physics, 1st Edition, P.Mayles, A. Nahum, J-C Rosenwald, Institute of Physics Publishing, 2007

Other Resources (Online Resources or others)

- Radiation Oncology Physics Slides by IAEA
- EMERALD, EMIT, EMITEL
- http://www.sprawls.org/resources/

20. Thesis on Radiation Oncology/ Nuclear Medicine/ Diagnostic and Interventional Radiology

Aim:

Students may choose from the future working area specific thesis topics for research. This part of the curriculum will encourage the students for Research of medical physics in diagnostic radiology, radiotherapy, and nuclear medicine with the ethics of conducting, presenting, and publishing research. The students will have the opportunity of impactful and innovative research under the direction of the Thesis Supervisor and the Supervisory Committee.

Objectives:

1. Demonstrate proficiency in presenting poster presentations, oral presentation, at national and international medical physics conferences, seminars, or scientific events.
2. Demonstrate the ability to integrate and synthesize interdisciplinary knowledge as well as summarize and interpret research results in Medical Physics. (in particular, to be able to apply critical thinking and analytical skills and to synthesize knowledge from Physics, Mathematics, Biology, and Computer Science, as applied to the Medical Physics field.)
3. Students will learn to develop quantitative measurement methods, plan, execute, and analyses relevant experiments, and model central physical, biochemical, or biological processes and systems within the subject area.

Course Contents

- **Thesis on Radiation Oncology/ Nuclear Medicine/ Diagnostic and Interventional Radiology:** Course is designed as per the needs of the project and set by the individual needs for designing experiment or survey, data collection, data interpretation, protocol, etc.
- Design and execute a thesis project in collaboration with clinical and academic co-supervisors.

Learning Resources

Textbooks

- Will be suggested by the thesis supervisor according to the research topics

Reference Books

- Will be suggested by the thesis supervisor according to the research topics

Other Resources (Online Resources or others)

- Will be suggested by the thesis supervisor according to the research topics

21. Accuracy Requirements and Uncertainties in Radiation Medicine

Aim:

To provide a comprehensive understanding of the accuracy requirements and uncertainties involved in radiation medicine and their impact on treatment outcomes.

Objectives:

1. To understand the radiobiological and clinical frameworks for accuracy in radiotherapy.
2. To familiarize with the definitions and terminology related to accuracy and uncertainties in radiation medicine.
3. To explore the sources of deviations from prescribed doses and their influence on treatment outcomes.
4. To examine practical strategies for managing uncertainties in radiation oncology.

Course Content

- **Introduction:** Background, Objective, Scope, Terminology, Radiobiological considerations, Clinical radiotherapy, Structure
- **The radiotherapy process:** Process overview, Patient identification, Treatment directive, Positioning and immobilization for treatment planning, Target and organ at risk volume delineation, Treatment planning, Patient immobilization and positioning for treatment delivery, Treatment delivery, Brachytherapy considerations
- **Definitions and terminology:** Introduction, Basic terms, Uncertainty, Error, Accuracy, Precision, Tolerance, Action level (maximum permissible error), Other comments on terminology, Summary
- Radiobiological Framework For Considering Accuracy Requirements: Introduction, Sources of deviations from prescribed dose, Description of dose–response curves, The influence of accuracy on treatment outcome, Statistical considerations of the accuracy needed in clinical studies
- **Clinical Framework for Considering Accuracy Requirements:** Medical aspects: harmonizing clinical data, Volumes in radiotherapy: concepts, definitions, and terminology, PTV dose escalation, Volume and dose distribution effects
- **Practically Achievable Levels of Accuracy:** Reference dosimetry, Relative dosimetry, and dose calculation, Patient positioning and immobilization, Imaging systems, Treatment delivery, Combined accuracy considerations
- **Managing Uncertainty:** Quality management versus managing quality, Cost–benefit, Research, determining uncertainties in the clinic, Presentation of uncertainties, Reducing uncertainties, Audits in radiation oncology

Learning Resources

Textbooks

- IAEA Human Health Series No-31, Accuracy Requirements, and Uncertainties in Radiotherapy, International Atomic Energy Agency, Vienna-2016

Reference Books

- The Modern Technology of Radiation Oncology, 2nd Edition, Van Dyke J (Ed.). Medical Physics. Medical Physics Publishing Corporation, 2005, Madison, WI, United States

Other Resources (Online Resources or others)

- Radiation Oncology Physics Slides by IAEA
- EMERALD, EMIT, EMITEL
- http://www.sprawls.org/resources/

24. Artificial Intelligence in Computer-Aided Diagnosis and Therapy

Aim:

To provide an in-depth understanding of the integration of Artificial Intelligence (AI) and Machine Learning (ML) in the diagnosis and therapy of medical conditions, emphasizing the role of Computer-Aided Diagnosis (CAD) systems and their evolving applications.

Objective:

1. To comprehend the foundational principles of AI and ML in medical diagnosis and therapy.
2. To explore the architecture and progression of CAD systems.
3. To investigate the clinical applications of AI and ML in both diagnosis and therapy.
4. To discuss ethical considerations and potential future advancements in AI.

Course Contents

- **Introduction:** Overview of AI and ML in medical physics, Evolution and significance of Computer-Aided Diagnosis (CAD)
- **Organization of a CAD System:** Structural components and operational workflow, Recent developments and improvements in CAD systems
- **Image Processing in CAD Systems:** Techniques for Image Enhancement, Methods of Image Segmentation, Processes for Feature Selection and Extraction
- **Data Analysis in CAD Systems:** Classification and Clustering methodologies, Techniques for Evaluation and Interpretation of CAD outcomes
- **Clinical Applications of CAD:** Implementation and impact of CAD in clinical settings
- **Clinical Applications of Machine Learning:** Use of ML for predictive analytics, Role of ML in automated decision-making and personalized treatment
- **Clinical Applications of Artificial Intelligence:** AI-driven planning in radiation therapy, AI in optimizing image-guided interventions
- **Ethical Issues in AI:** Addressing patient privacy and data protection, Ensuring fairness and reducing bias in AI algorithms, Maintaining accountability and transparency in AI systems
- **Future Prospects of AI:** Exploration of emerging AI technologies and methodologies, Assessing the potential future impact of AI on healthcare
- **Practical Session:** Interactive hands-on experience with AI tools, Development and evaluation of simple AI models tailored for medical applications

Learning Resources

Textbooks

- ER Ranschaert, S Morozov, PR Algra (Eds) (2019). Artificial Intelligence in Medical Imaging: Opportunities, Applications, and Risks, 1st Edition, Germany: Springer.
- L Morra, S Delsanto, L Correale (2019). Artificial Intelligence in Medical Imaging: From Theory to Clinical Practice. 1st Edition, CRC Press.
- KC Santosh, S Antani, DS Guru, N Dey (Eds) (2020). Medical Imaging: Artificial Intelligence,

- Image Recognition, and Machine Learning Techniques. 1st Edition, New York: CRC Press.

Reference Books

- G Wu, D Shen, M Sabuncu (2016). Machine Learning and Medical Imaging. 1st edition, UK: Elsevier Inc.
- JD Peter, SL Fernandes, CE THomaz, S Viriri **(2019).** Computer Aided Intervention and Diagnostics in Clinical and Medical Images. Lecture Notes in Computational Vision and Biomechanics 31. Springer International Publishing.
- Qiang Li, RM Nishikawa (Eds) (2015). Computer-Aided Detection and Diagnosis in Medical Imaging. 1st Edition, CRC Press.
- PM de Azevedo-Marques, A Mencattiin, M Salmeri, RM Rangayyan. Medical Image Analysis and Informatics: Computer-Aided Diagnosis and Therapy. 1st Edition. CRC Press. 2018.

Other Resources (Online Resources or others)

- Python
- Matlab

25. Health Technology Assessment

Aim:

To provide a comprehensive understanding of Health Technology Assessment (HTA), including its methodology, regulatory aspects, economic evaluations, and the assessment of health-related quality of life.

Objectives:

1. To understand the components and methodology of an HTA report.
2. To learn the regulatory approval process for health devices.
3. To master the steps involved in conducting a Health Technology Assessment.
4. To evaluate costs, economic impact, and burden of illness studies.
5. To understand and apply principles of health-related quality of life assessments.

Course Contents:

- **General Aspects Related to an HTA Report:** General Impressions: Overview and initial evaluation of the HTA report, Motivation for the Report: Reasons and objectives behind conducting the HTA, Methodology Used: Approaches and methods employed in the assessment, Interpretation of Available Information: Analyzing and understanding the data and findings, Implementation of Findings: How the results are applied in practice and decision-making
- **Regulatory Approval for Devices:** Process Overview: Steps and requirements for obtaining regulatory approval for health technologies
- **Health Technology Assessment:** Step 1: Identify the Topic for Assessment: Choosing and defining the subject of the assessment, Step 2: Clear Specification of the Problem: Detailing the problem and scope of the assessment, Step 3: Gathering the Evidence: Collecting relevant data and information, Step 4: Aggregation and Appraisal of the Evidence: Evaluating and summarizing the collected evidence, Step 5: Synthesize and Consolidate Evidence: Integrating findings to form a coherent analysis, Step 6: Collection of Primary Data (Field Evaluation): Conducting field studies and primary data collection, Step 7: Economic Evaluation: Assessing the economic impact and cost-effectiveness of the technology, Step 8: Budget and Health Systems Impact Analysis: Analyzing financial implications and system-wide effects, Step 9: Assessment of Social, Ethical, and Legal Considerations: Evaluating the broader impact of the technology, Step 10: Formulation of Findings and Recommendations: Developing conclusions and suggestions based on the assessment, Step 11: Dissemination of Findings and Recommendations: Communicating the results to stakeholders, Step 12: Monitoring the Impact of Assessment Reports: Tracking the effects and implementation of HTA findings
- **Costs and Cost of Illness Studies:** From Clinical Events to Resource Utilization to Costs: Mapping clinical events to resource use and costs, Measurement of Resource Utilization: Techniques for measuring and tracking resource use, Attribution and Adjustment for

Comorbidities: Handling comorbid conditions in cost assessments, Strategies to Isolate the Cost of an Event: Methods for isolating specific event costs, Regression Methods and Other Strategies to Estimate Costs: Statistical approaches for cost estimation, Unit Costs Valuation for Resources: Valuing resources and calculating unit costs, Perspective and Types of Costs: Different perspectives (e.g., societal, healthcare) and cost types, Burden of Illness Study: Evaluating the overall impact of illness on individuals and society, Budget Impact Analysis: Assessing the financial impact on budgets, Statistical Issues with Cost Data: Challenges and methods in analyzing cost data

- **Health-Related Quality of Life:** Why QOL?: Importance and relevance of quality-of-life assessments, Good Properties of Scales: Criteria for selecting appropriate quality of life scales, Guidelines for Using QOL in HTA: Best practices for integrating QOL data into HTA, From Utility to QALY: Converting quality of life measures to Quality-Adjusted Life Years (QALYs), Assessing Change in QOL Scales: Evaluating changes in quality of life over time, Minimal Clinically Important Difference for HRQOL: Determining the smallest change in quality of life that is clinically significant, Obtaining QOL Estimates from Trials and Literature: Collecting and interpreting QOL data from research, Independent QOL Study: Conducting standalone studies focused on quality of life, Mapping Between QOL Scales: Converting data between different quality of life scales

Learning Resources

Textbooks

- Health Technology Assessment: Using Biostatistics to Break the Barriers of Adopting New Medicines 1st Edition, Kindle Edition by Robert B. Hopkins MA MBA Ph.D. (Author), Ron Goeree MA (Author), Taylor & Francis (2014)

Reference Books

Health Technology Assessment of Medical Devices by World Health Organization, 2012.

26. Microdosimetry/Advanced Radiation Dosimetry

Aim:

To provide a comprehensive understanding of microdosimetry principles and advanced dosimetric techniques, focusing on their applications in radiation therapy, radiation protection, and space science.

Objectives:

1. To understand microdosimetric quantities and their relevance in energy deposition processes.
2. To learn measurement techniques for microdosimetric quantities.
3. To explore dual radiation action theories in various radiation fields.
4. To assess microdosimetry's role in low-dose radiation protection and its applications in medical and space environments.
5. To gain insights into the calibration and dosimetry of photon and electron beams using advanced tools and methodologies.

Course Contents:

- **Microdosimetric Quantities and the Compound Poisson Process in Radiation Energy Deposition:** Measurement of microdosimetric quantities, Dual radiation action and compound dual radiation action, Microdosimetry and low-dose radiation protection science, Microdosimetry and low-energy X-rays used in medical diagnosis and therapy, Microdosimetry of high-LET radiation used in radiotherapy, Microdosimetry and space radiation protection science
- **Description of Ionizing Radiation Fields:** Quantities for describing radiation interaction, Charged particles and charged particle interactions, Cavity theory and ionization chambers
- **Dosimetry and Calibration:** Dosimetry and calibration of photon and electron beams, Passive dosimeters for photon and electron beams

Learning Resources

Textbooks

- The Dosimetry of Ionizing Radiation, Volume III, Ed. Kase, Bjarngard and Attix, Academic Press, 1990;
- PODGORSAK, E. B., Radiation Physics for Medical Physicists (Biological and Medical Physics, Biomedical Engineering), 2nd Edition, Springer, New York, USA (2010).
- F.M. Khan, The Physics of Radiation Therapy, 3rd Edition, Lippincott Williams and Wilkins, 2003;

Reference Books

- Design, Construction and Use of Tissue Equivalent Proportional Counters, Ed. Schmitz, Waker, Kliauga and Zoetelief, Radiat. Prot. Dosim, 64, No 4, 1995;
- Proceedings of Micodosimetry Symposia, 1967-2006; Radiation Detection and Measurement – 4th Edition, Knoll, G., 2010.
- Miscellaneous ICRU and NCRP Reports

Other Resources (Online Resources or others)

- Radiation Oncology Physics Slides by IAEA
- EMERALD, EMIT, EMITEL
- http://www.sprawls.org/resources/

27. Particle Therapy or Special Techniques

Aim:

The course objective is to understand the general theory, concepts, and methods used in radiotherapy, including also particle therapy. The course will provide knowledge into the theory and methods that are applied for the treatment of cancer with ionizing radiation both using photons and particles. This will include several subjects with the main being: introduction to the use of external beam radiation therapy, basic physics interactions, and dosimetry, particle accelerators for radiation therapy, how to derive a dose distribution including different treatment techniques, dose optimization, basic radio-biological interactions, and their impact on treatment and methods for treatment delivery.

Objectives:

1. Demonstrate understanding of the capabilities and limitations of all different irradiation techniques
2. Demonstrate understanding of current and state-of-the-art treatment techniques for all relevant treatment sites
3. Ability to implement all treatment techniques, from commissioning to treatment simulation, planning, verification, and quality assurance
4. Ability to choose the most appropriate technique according to the tumor site and intent of the treatment
5. Ability to compare national and international treatment protocols for different irradiation techniques with those used at the institution.

Course Contents:

- **Conformal and Intensity-Modulated Radiotherapy:** General overview, optimization, and Inverse Planning, intensity-modulated beam delivery.
- **Intensity-Modulated Radiotherapy:** Practical Aspects Introduction, requirements for clinical implementation, guidelines on IMRT treatments.
- **Stereotactic Techniques:** Introduction, clinical indications, radiosurgery equipment, linear accelerator-based radiosurgery, stereotactic frames, stereotactic fiducial systems, stereotactic treatment planning, beam data measurement, treatment setup, pretreatment quality assurance, stereotactic conformal treatments and QA, accuracy and isodose prescription, stereotactic radiotherapy to extra-cranial Si, conclusion
- **Image Guided Radiotherapy(IGRT):** Techniques of patient positioning and target localization in radiation therapy (simulation, portal imaging, positioning support system/mask system), inaccuracies concerning positioning accuracy and Dosimetry; Localization by Ultrasound; Localization by 2-D x-ray (portal imaging, fiducial marker), 3D-CT (cone beam CT, gantry mounted volume imaging); Adaptive radiation therapy.

- **Proton Beams in Radiotherapy:** Introduction, physical basis the interactions of protons with matter, technological basis of proton therapy, treatment implementation, clinical applications, economic and functional considerations, conclusion
- **Total Body Irradiation:** Clinical goals, dose and dose rate, dose specification, available techniques, Dosimetry considerations, Dosimetry considerations.
- **Total Skin Electron Irradiation:** Introduction, general clinical and patient-related problems, physical and practical requirements, conclusions.
- **High-LET Modalities:** Therapy with neutrons, boron neutron capture therapy, light, heavy ions.

Learning Resources

Textbooks

- Radiation Oncology Physics: A Hand book for Teachers and Students, International Atomic Energy Agency, Vienna, 2005
- Hand book of Radiotherapy Physics, 1st Edition, P.Mayles, A. Nahum, J-C Rosenwald, Institute of Physics Publishing, 2007.
- Khan's The Physics of Radiation Therapy, Sixth Edition by Faiz M. Khan Ph.D. (Author), John P. Gibbons Ph.D. (Author), (2019)

Reference Books

- The Modern Technology of Radiation Oncology, 2nd Edition, Van Dyke J (Ed.). Medical Physics. Medical Physics Publishing Corporation, 2005, Madison, WI, United States
- The Modern Technology of Radiation Oncology. Van Dyke J (Ed.). Medical Physics Publishing. Publisher: Medical Physics Publishing Corporation,2013

Other Resources (Online Resources or others)

- Radiation Oncology Physics Slides by IAEA
- EMERALD, EMIT, EMITEL
- http://www.sprawls.org/resources/

28. Management Principles

Aim:

The roles of medical physics need to be redefined and reinvigorated, and furthering leadership roles was identified as a key focus. Inevitably, most medical physicists are called upon to be actively involved in major decision making at their places of business, and this includes managing human resources, administrative oversight, consulting, budgeting, grand capital purchasing, and strategic planning, all of which are duties that require a wide array of leadership qualities. This course is intended to address the need to improve leadership in the medical physics profession and to provide adequate knowledge and skills for developing their leadership and management skills.

Objectives:

1. Demonstrate an understanding of the position of the own institution as part of the organisation of healthcare at local and national levels
2. Ability to acquire the directives of healthcare management, national regulations and guidelines, and/or recommendations from national and international organisations
3. Demonstrate knowledge of management and leadership in medical practice
4. Develop the knowledge of management for Advancing Career

Course Contents:

- **Tools of the Trade:** Developing Yourself, Communicating Effectively: Balancing Content and Connection, Giving and Receiving Feedback, Managing Conflict, Managing Your Time, Mindful Leadership, Prioritizing and Decision-Making
- **Management:** Principles of Management, Running Effective Meetings, Conducting Effective Retreats, Recruitment, Retention, and Dismissal, Managing Managers, Promoting Professionalism and Professional Accountability, Creating a Culture of Inclusion Through Diversity and Equity
- **Leadership:** The Leadership Stance, Leadership Presence, Forming and Reforming Workplace Culture, Coaching and Mentoring, Leading Up, Leading Without Line Authority, Political Savvy, Moral Courage, Leading Change, Thinking Strategically
- **Advancing Your Career:** Growing in Your Current Role: Reaching the Next Rung on the Faculty Development and Promotion in Academic Medicine, Moving Out to Move Up, Executive Development

Learning Resources

Textbooks

- Management and Leadership Skills for Medical Faculty and Healthcare Executives: A Practical Handbook by Anthony J. Viera, Rob Kramer, 2nd Edition, Springer Nature Switzerland AG 2020

Reference Books

- Hari Singh, Essentials of Management for Healthcare Professionals, 1st Edition, Productivity Press; Taylor & Francis, 2018.
- Operations Management in Healthcare: Strategy and Practice, Corinne M. Karuppan, Michael R. Waldrum, Nancy E. Dunlap, Springer, 2016
- Management and Leadership Skills for Medical Faculty and Healthcare Executives: a practical handbook, 2nd Edition, Anthony J. Viera, Rob Kramer, Springer Nature, 2020

29. Physics of Human Body

Aim:

To provide a comprehensive understanding of the fundamental physical principles underlying the functioning of the human body, with an emphasis on their application in medical diagnostics and treatment.

Objectives:

1. To explain the physical properties of body fluids and their significance in physiological processes.
2. To elucidate the electrical activities of the heart and brain and their importance in medical diagnostics.
3. To introduce the principles of biophysics in understanding the dynamics of the cardiovascular and nervous systems.
4. To discuss the physics behind sound, optics, and other forms of energy and their medical applications.
5. To explore the implications of pressure and electricity within the body and their roles in various physiological systems.

Course Contents:

- **Body fluid:** Properties of body fluid, determination of conduction of body fluid, measurement of EMF of cells, temperature and reaction rates: Arrhenius equation. Photochemical reaction, the law of photochemistry, Principles of colorimeter, Beer-Lambert's law, biometrics, Bernoulli's equation & application of B, principles in CVS, blood flow –laminar & turbulent.
- **Biophysical activity of heart:** Electrical activity of the heart, regular and ectopic pacemakers, electrocardiography, waveform and measurement, ECG in diagnosis.
- **Biophysical activity of brain and other organs:** Electrical activity of brain, waveforms & measurements, recording electrodes, interfaces, skin contact impedance, biological transducers, receptor potentials.
- **Introduction to electrical stimulation:** Impedance & current distribution, dielectric properties of biological materials, skin impedance, total body impedance, patient safety, electrical shocks and hazards, leakage currents, types and measurements, protection against shock, burn and explosion hazards
- **Physics (Sound and Optics):** Physics of sound, Normal sound level, Theories of hearing, Measurement of hearing, hearing aid, Instruments used in ophthalmology, Medical Application of Visible light, UV light, Infrared and Laser, Heart sound.
- **Force in Body:** Static force, frictional forces, dynamics.
- **Physics of the skeleton:** Composition of bones; lubrication of bone joint, measurement mineral in the body.

- **Heat and Cold in medicine:** Physical basis of heat and temperature, thermometry and temperature scales, heat therapy, use of cold in medicine, cryosurgery, safely with cryogenics.
- Energy. work and power in the body: Conservation of energy in the body, energy changes in the bodywork and power, heat losses from the body
- **Pressure in the body:** Measurement of pressure in the body, pressure inside the skull, eye pressure, pressure in the digestive system, in the skeleton and in the urinary bladder, pressure effect while diving, hyperbolic oxygen, therapy
- **Physics of the lungs and breathing:** The airways how the blood and lungs interact, measurements of lung volume, the breathing mechanics airway resistance, work of breathing, physics of some common lung diseases physics of the cardiovascular system.
- **Electricity within the body**: The nervous system and the neuron electrical potentials of nerves Electrical signals from muscles, heart, brain and eye magnetic signal, from heart and brain

Learning Resources

Textbooks

- Irving P. Herman. 2015. Physics of the human body. 2nd Edition. Springer International Publishing, New York, NY, USA.
- John R. Cameron, James G. Skofronick, Roderick M. Grant. 1999. Physics of the body. 2nd Edition. Medical Physics Publishing, Madison, USA.

30. Optical Imaging

Aim:

Optical imaging has played a critical role in almost all major breakthroughs in recent medical research. Knowledge of current optical imaging technologies is important for students who plan for future careers or graduate studies in medicine related fields.

Objectives:

1. **Understand the Fundamentals**: Gain a comprehensive understanding of the principles of light microscopy and electronic imaging as they apply to biomedical sciences.
2. **Explore Current Technologies**: Familiarize with current optical imaging technologies and their applications in medical research.
3. **Analyze Imaging Techniques**: Develop skills to analyze and interpret data from various biomedical optical imaging techniques.
4. **Apply Knowledge to Research**: Apply knowledge of optical imaging in designing and conducting research in medicine-related fields.
5. **Evaluate Advancements**: Critically evaluate recent advancements and innovations in optical imaging and their impact on medical diagnostics and treatment.

Course Contents:

- **Introduction to Optics, Optical Properties of Tissue, and Photon-Tissue Interactions:** Introduction to optics, Optical properties of tissue, Photon-tissue interactions
- Monte Carlo Simulation, Sensing of Optical Properties and Spectroscopy
- **Imaging Techniques:** Ballistic imaging, Wide-field and dark-field microscopy, Polarization, phase contrast, and differential interference contrast microscopy (DIC) microscopy, Fluorescence microscopy, Confocal microscopy, Two-photon microscopy, Optical coherence tomography, Super-resolution imaging

Learning Resources

Textbooks

- Fundamentals of Light Microscopy and Electronic Imaging, 2nd Edition, Douglas B. Murphy, Wiley-Liss, ISBN: 0-471-25391-X, 2012

Reference Books

- Biomedical Optics: Principles and Imaging, Lihong V. Wang and Hsin-i Wu, Wiley Interscience, 1st Edition, 2007.
- Biomedical Photonics Handbook, 2nd Edition, Tuan Vo-Dinh, CRC Press, 2014
- Tissue Optics, Valery Tuchin, SPIE Press, 3rd Edition, 2014
- Handbook of Biological Confocal Microscopy, James B. Pawley, 3rd Edition, Springer, 2016

31. Theranostics

Aim:

The objective of this course is to provide knowledge with consolidated experience in basic Nuclear Medicine and intends its application in oncologic conditions using integration of diagnostic and therapeutic nuclear medicine techniques in the individualized management of disease (Theranostics). Students will acquire skills and competences through this course which will enable them to enhance this practice to improve the quality of life of cancer patients and patients with relevant conditions.

Objectives:

1. Improve comprehensive knowledge of Epidemiology, Causes, risk factors, clinical manifestations/symptoms of some types of cancers.
2. Demonstrate the role of nuclear medicine in the diagnosis and treatment of relevant oncologic conditions.
3. Review the different established and emerging imaging and therapeutic nuclear medicine protocols and nuclear techniques in the evaluation and management of cancer.
4. Discuss about the Nanoparticle Detection and Quantification: In Vitro and in Vivo Techniques

Course Contents:

- **Aberrant Signaling Pathways:** Cancer, Pathways Deregulated in Cancer: Introduction, Introduction to Nanotechnology, Overview of Clinical Nanotechnology, Current Usage in Cancer Treatment, Current Uses in Cancer Diagnostic,
- **Application of Nanoparticles in Cancer Treatment:** Introduction, Nanotechnology, Nanobiotechnology, Nanotechnology in Medicine, Cancer and Nano in Medicine, Nanoparticles in Cancer Treatment, Nanoparticle Platforms as Drug Delivery Systems for Cancer Therapy, Theranostic Nanomedicine, Theranostic Nanomedicine for Cancer Therapy, Selective Drug Delivery and Encapsulation for Chemotherapy, Stimuli-Sensitive Nanopreparations, Multifunctional Nanopreparations, Cancer Nanotechnology: Future and Challenges
- **Biomacromolecule-Gated Mesoporous Silica Drug Delivery**: Systems for Stimuli-Responsive Controlled Release: Introduction, Protein-Gated MSN Drug Delivery Systems, DNA-Gated MSN Drug Delivery Systems, Conclusions and Perspectives
- **Construction of Functional DNA Nanostructures for Theranostic Applications:** The Progress of Structural DNA Nanotechnology, DNA Nanostructures for Diagnostics, DNA Nanostructures for Diagnostics on the Interface, Diagnostic in Homogeneous Solution, DNA Nanostructures for Therapeutics, Integration of Diagnosis and Therapy: Smart DNA Theranostic Nanodevices, Targeted Delivery, Controlled/Triggered Release, Summary and Perspectives

- **Imaging and Therapeutics Introduction**: Nanoparticle-based Drug Delivery Systems, Nanoparticles for Drug Delivery in Cancer Treatment, Magnetic Nanoparticles (MNP), Nanoparticle Biodistribution and Degradation.
- **Nanoparticle Detection and Quantification:** In Vitro and in Vivo Techniques: Optical Microscopy, Colorimetric Assays, Transmission Electron Microscopy, Magnetic Methods, Elemental Analysis, Nuclear Magnetic Resonance (NMR), Evaluation of Nanoparticle-Induced Toxicity, Magnetic Targeting of Nanoparticles, A Specific Example: DMSA-Coated Magnetic Nanoparticles

Learning Resources

Textbooks

Advanced Theranostic Materials by Ashutosh Tiwari, Hirak K. Patra and Jeong-Woo Choi, 2015

V. Implementation Guidelines

By following these implementation guidelines, educational institutions can effectively adapt the AFOMP Medical Physics Syllabus to their specific needs while maintaining high standards of education across the region.

A. Adapting the Syllabus to Local Conditions

The AFOMP Medical Physics Syllabus is designed to be flexible and adaptable to various educational contexts across the Asia-Oceania region. When implementing this syllabus:

1. Consider local healthcare needs and technological resources.
2. Align the content with national regulatory requirements and professional standards.
3. Adjust the depth and breadth of each topic based on the specific focus of your program (e.g., diagnostic vs. therapeutic medical physics).
4. Incorporate case studies and examples relevant to local medical practices and equipment.
5. Collaborate with local hospitals and clinics to ensure practical training aligns with industry needs.

B. Assigning Credits

The assignment of credits for each course within this syllabus should be guided by the following principles to ensure a standardized and comprehensive educational experience. Credits should reflect the depth and breadth of the content, the expected student workload, and the level of learning outcomes achieved. Here is a general framework for assigning credits:

1. Credit Hours Definition

Lecture Credit: One credit hour typically corresponds to one hour of classroom or direct faculty instruction and a minimum of two hours of out-of-class student work per week.

Laboratory Credit: One credit hour for laboratory courses typically corresponds to two to three hours of laboratory work per week.

Clinical/Practical Credit: One credit hour corresponds to a minimum of three hours of clinical or practical work per week.

Independent Study/Research Credit: One credit hour corresponds to a minimum of three hours of student work per week under the supervision of a faculty member.

2. Total Credit Calculation

The total number of credits for the entire syllabus should be calculated by summing the individual course credits. This total should align with the degree requirements for medical physics programs, typically ranging from 120 to 150 credits for undergraduate programs and 30 to 60 credits for graduate programs, depending on the educational institution's policies.

3. Flexibility and Electives

Institutions should offer flexibility in elective courses, allowing students to choose based on their interests and career goals.

Elective courses can cover advanced topics, specialized areas within medical physics, or interdisciplinary subjects, each with appropriate credit assignments based on the depth and workload.

4. Continuous Assessment and Credit Adjustments

Institutions should regularly review and adjust credit assignments based on course evaluations, feedback from students and faculty, and advancements in the field of medical physics.

This ensures that the syllabus remains relevant, comprehensive, and aligned with current educational standards and industry needs.

By following this framework, educational institutions can ensure a balanced, rigorous, and comprehensive approach to assigning credits within the medical physics syllabus, fostering a well-rounded education for future medical physicists.

C. Integration into Existing Programs

To effectively integrate this syllabus into existing medical physics programs:

1. Conduct a gap analysis between the current curriculum and the AFOMP syllabus.
2. Gradually phase in new content over several academic cycles to minimize disruption.
3. Provide faculty training on new topics or teaching methodologies introduced by the syllabus.
4. Develop interdisciplinary collaborations to cover topics that may require expertise from other departments.
5. Regularly review and update course materials to reflect the latest developments in medical physics.

D. Teaching Methodologies

To enhance the learning experience and address the diverse needs of students across the AFOMP region, the following teaching methodologies are suggested:

1. Blended Learning: This approach combines traditional classroom instruction with online learning resources, offering flexibility for students to engage with the content at their own pace. It ensures that students have access to high-quality educational materials, regardless of their geographical location.

2. Collaborative Learning: Emphasizing group-based activities, such as peer-to-peer learning, problem-solving sessions, and project-based tasks, this method fosters collaboration and teamwork. It encourages students to share knowledge and learn from diverse perspectives.

3. Virtual Expert Sessions: Digital platforms can be used to invite experts from developed countries within the AFOMP region to deliver virtual lectures, workshops, and interactive sessions. This enables students in lower- and middle-income countries to benefit from the expertise of leading professionals, bridging gaps in resource availability.

4. Simulation and Case-Based Learning: Utilizing real-life scenarios and case studies, this method simulates clinical situations, allowing students to apply theoretical knowledge in practical contexts. It enhances critical thinking and decision-making skills.

5. Hospital Visits: Organized visits to hospitals and medical centers provide students with firsthand experience of clinical environments. These visits allow students to observe the application of theoretical knowledge in real-world settings, interact with healthcare professionals, and understand the workflow and challenges in clinical setups.

6. Continuous Assessment and Feedback: Regular assessments, including quizzes, assignments, and practical exercises, should be integrated into the curriculum. Continuous feedback helps students identify areas for improvement and track their progress throughout the course.

These suggested methodologies aim to provide a comprehensive and accessible education, tailored to meet the needs of all students within the AFOMP region, regardless of their resources or location.

E. Assessment Methods

A comprehensive assessment strategy should be employed to evaluate student learning:

1. Continuous Assessment:
   - Regular quizzes and problem sets
   - Laboratory reports and practical skills evaluations
   - Case study analyses and presentations
   - Research projects and literature reviews
2. Examinations:
   - Mid-term and final written exams for each core topic
   - Practical exams to assess hands-on skills
   - Oral examinations to evaluate comprehensive understanding and communication skills
3. Clinical Competency Assessments:
   - Supervised clinical rotations with performance evaluations
   - Competency checklists for key clinical skills
   - Portfolio development documenting clinical experiences

4. Research and Development Skills:
    - Research proposal writing and evaluation
    - Participation in ongoing research projects
    - Presentation at student symposia or conferences
5. Professional Skills Assessment:
    - Ethical case studies and discussions
    - Simulated multidisciplinary team exercises
    - Communication skills workshops and evaluations
6. Capstone Project:
    - A comprehensive project integrating multiple core topics
    - Written thesis and oral defense

Ensure that assessment methods are aligned with learning objectives and provide opportunities for both formative and summative evaluation. Regular review and adjustment of assessment strategies will help maintain their effectiveness and relevance.

VI. References

- American Association of Physicists in Medicine (2009). AAPM Report 197: Academic Program Recommendations for Graduate Degrees in Medical Physics. New York: American Institute of Physics.
- International Atomic Energy Agency (2013). Postgraduate Medical Physics Academics Programme. Training Course Series, TCS-56. Vienna: IAEA.
- International Atomic Energy Agency (2014). IAEA Safety Standards Series No. GSR Part 3. Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards. Vienna: IAEA.
- International Atomic Energy Agency (2021). Postgraduate Medical Physics Academics Programme. Training Course Series, TCS-56 (Rev. 1). Vienna: IAEA.
- International Organization for Medical Physics (2010). IOMP Policy Statement 1. The Medical Physicist: Role and Responsibilities. Available at: https://www.iomp.org/wp-content/uploads/2019/02/iomp_policy_statement_no_1.pdf
- International Organization for Medical Physics (2010). IOMP Policy Statement 2. Basic Requirements for Education and Training of Medical Physicists. Available at: https://www.iomp.org/wp-content/uploads/2019/02/iomp_policy_statement_no_2_0.pdf

VII. AFOMP Contact Information

Contact details for AFOMP, including address, phone number, email, and website for further inquiries and support.

Asia Oceania Federation of Organizations for Medical Physics

Official website: https://afomp.org/

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AFOMP has LinkedIn and Twitter (X) profiles and a YouTube channel through which AFOMP activities, medical physics news etc. are shared. Follow the accounts to keep ourselves updated with the AFOMP educational and professional activities.

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